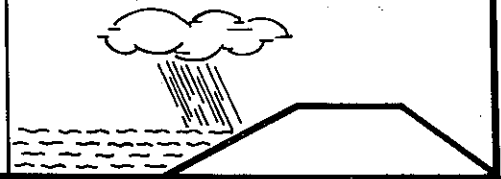


GUIDELINES FOR THE DESIGN AND CONSTRUCTION OF SMALL EMBANKMENT DAMS

*Division of
Safety of Dams*



California Department of Water Resources

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

Guidelines for the Design
and Construction of Small
Embankment Dams

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4.	Outlet Profile and Sections
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PURPOSE AND SCOPE

The purpose of these Guidelines is principally to provide those potential owners of small dams with a fairly complete description of the legal and engineering requirements that they must meet if they desire to construct and own a small dam in California. The requirements illustrated apply specifically to small dams in those rural areas where downstream hazards are minimal. The engineering requirements illustrated apply to a hypothetical, specific dam at a specific site. Since conditions and materials vary widely from actual site to site, it should be recognized that the Guideline specifications and drawings included herein could not apply without many modifications in an actual case.

These guidelines were published in March 1977. The only changes subsequent reprints have been corrections of minor errors and to update addresses for the Division of Safety of Dams and other agencies.

FOREWORD

The sudden failure of St. Francis Dam in Southern California in 1928 resulted in a major disaster. Because of this failure and because of the potential hazard to the general populace from the many water storage projects in California, the Legislature in 1929 enacted a law providing supervision, for safety, of dams across natural watercourses. Following the failure of Baldwin Hills Dam in Southern California in 1963, the Water Code was amended by the Legislature in 1965 to include within State jurisdiction both new and existing offstream storage facilities and entire reservoirs as well as dams.

Division 3 of the California Water Code placed the supervision for safety of all dams and reservoirs larger than a specified minimum size under the jurisdiction of the California Department of Water Resources. Federal dams are exempt from the Code. These Code provisions are administered by the Department through the Division of Safety of Dams. The Division independently analyzes and evaluates plans and specifications for constructing new dams and for enlarging, repairing, altering, or removing existing dams and must grant approval in writing before the owner

may proceed with construction. The Division inspects and evaluates each dam and reservoir during construction to verify compliance with the approved plans and specifications and to assure that changes or unforeseen foundation conditions are recognized and the design is modified as necessary. The Division inspects, monitors, and evaluates operational dams annually or more frequently as necessary to assure safety. The Division issues a Certificate of Approval for each dam and reservoir, containing operational restrictions if necessary for safe use.

CHAPTER I

INTRODUCTION

General

These guidelines are intended to illustrate the general minimum requirements of the Department of Water Resources, Division of Safety of Dams, for the design and construction of a small earthfill dam. They are further intended as a supplement to the Water Code to assist an owner and his engineer in arriving at an acceptable design and adequate plans and specifications, with a minimum of effort. These guidelines obviously are not intended to constitute a text for the design and construction of small embankment dams. Instead, they merely present a sample for an assumed embankment dam on dense soil or rock foundation of typical provisions which will be required in an actual design. Ultimate determinations by the Division of the acceptability of design and adequacy of plans and specifications must, by necessity, be made on a case by case basis. Therefore, the Division cannot warrant that compliance with these guidelines will result in a totally satisfactory design.

In general, the guidelines are intended only for small earthfill dams located in rural type settings, with heights ranging up to 50 feet, with no unique foundation or embankment problems, and with minimal potential for downstream damage.

No explanation is given as to the reasons for some of the requirements, since most will be self-explanatory to a knowledgeable civil engineer. The drawings and specifications, which are part of these Guidelines, depict an assumed small embankment dam. They are only intended to indicate recommended format and minimum design requirements.

As stated above, the Guidelines are suggestive only, and the owner or his engineer is not precluded from developing new ideas or procedures that may differ from them. The Division's objective is to obtain safe dams. This can be accomplished generally in the manner indicated in these Guidelines, together with reasonable modifications appropriate to the individual problems at each damsite.

Inasmuch as the approval of an application to construct a dam does not grant the right to appropriate water, the applicant must apply for a water right permit through the State Water Resources Control Board prior to filing an application to construct a dam. For private owners of dams, this will initiate action for conformance with the requirements of the California Environmental Quality Act of 1970. These requirements are explained in detail under "Environmental Considerations".

Application

An application for approval of plans and specifications must be

filed in duplicate by the owner or his duly appointed representative for dams which will be 25 feet or more in height, measured vertically from the lowest elevation of the outside limit of the dam to the maximum possible water storage elevation, or which will have an impounding capacity of 50 acre-feet or more. Barriers which will be 6 feet or less in height or which will have a storage capacity not in excess of 15 acre-feet are not considered dams and no application is required.

Application blanks, along with a copy of the "Statutes and Regulations Pertaining to Supervision of Dams and Reservoirs", can be obtained free from the Department of Water Resources, Division of Safety of Dams, at 2200 X Street, Suite 200, Sacramento, California. Mail requests should be sent to the Post Office Box shown on the title page. This publication contains the appropriate provisions of the State Water Code and the California Administrative Code with reference to the State's role in the supervision of safety of dams.

Administrative Procedures

Construction of a new dam shall not begin until the owner has applied for and obtained from the Department of Water Resources, Division of Safety of Dams, written approval of his application, which includes plans and specifications.

The first step in the procedure for obtaining approval to construct a dam is to file an application for a water right with the State Water Resources Control Board, Division of Water Rights, 901 P Street, Sacramento, California 95814. The next step is to file an application, in duplicate, with the Department of Water Resources, Division of Safety of Dams, with a copy to the State Department of Fish and Game, Room 1206-20, Resources Building, 1416 Ninth Street, Sacramento, California 95814.

The application for construction of a dam should include duplicate copies of plans and specifications prepared by a registered civil engineer; a filing fee based on the estimated construction cost of the dam; and any other information which will provide the Division a basis for reviewing the design of the dam and appurtenances. Depending on the complexity of the project, dam siting conditions, and other inherent characteristics, the Division will usually require some additional information in the form of geological investigation, physical testing to determine properties and behavior of the foundation and embankment materials, hydrologic data, and structural and hydraulic design notes.

After review of the plans and specifications, etc., and inspection of the site, the application will be either approved, rejected, or changes in the plans and specifications will be required.

The construction work shall be under the responsible charge of a registered civil engineer. During construction the Division will make periodic inspections for the purpose of securing conformity with the approved plans and specifications, and will require the owner to perform such work or tests as necessary to disclose information sufficient to enable the Division to determine that such conformity is being obtained. Usually, such testing will be limited to verification of embankment compaction, concrete strengths, and other similar requirements. Modifications to the plans and specifications may be required if unforeseen conditions develop during construction.

Immediately after completion of construction the owner must file a notice of completion with the Division, and as soon as possible after that he must file with the Division supplementary drawings showing the dam and reservoir as it was actually constructed.

The owner, also as soon as possible, must file a Cost Statement (DWR 824) stating the actual cost of the dam and reservoir. It must be accompanied by a detailed cost breakdown. If the final cost is over 115 percent of the estimated cost a further fee is due.

As soon as practicable after construction, the dam and reservoir will be inspected by the Division, and upon finding that the dam and reservoir is safe to impound water, a certificate of approval

to store water will be issued. Water cannot be stored until this certificate is issued.

The dam owner is charged an annual fee based on the height of the dam. The Division, usually annually, inspects each dam and reservoir for signs of embankment erosion, rodent damage, seepage, spillway blockage, and other signs of general deterioration or distress. The owner at his expense will be required to correct any deficiencies.

Environmental Considerations

Provisions of the California Environmental Quality Act of 1970 must be satisfied before a construction application can be considered for approval. If the owner is a public agency, it will be the "lead agency" and will prepare the required documents and file them with both the local and State clearinghouses.

If the owner is a private entity, the public agency with the principal responsibility for supervising or approving the project as a whole will be the "lead agency". In the case of small dams, the "lead agency" is usually the State Water Resources Control Board, Water Rights Division, unless the county in which the dam is located requires a development, grading, or zoning permit, in which case the county would be the "lead agency". If an Environmental Impact Report is required, the owner must pay the "lead agency" the cost of preparing the report. Environmental

documentation for dams must be filed with the State Clearinghouse regardless of who is the lead agency.

Preparation of the environmental documents and processing them in both the local and State clearinghouses takes considerable time. The minimum is about six months.

CHAPTER II

FOUNDATIONS AND CONSTRUCTION MATERIALS

General

Information concerning geology, seismicity, foundation conditions, and construction materials is essential even for the design and construction of a small earth dam. Preconstruction investigation and testing are required to determine whether a safe dam can be constructed at the proposed site, and the data obtained will assist in the planning, design, and construction of the dam, spillway, and outlet facilities.

The Division of Safety of Dams should be notified when an exploration investigation is being done so that the field work can be observed. This could preclude a possibility of having to do additional exploration for the benefit of the Division.

After the investigation and testing are completed, all the information should be included in a geology, foundation, and construction materials report. This report must be submitted to the Division as support data for the design and construction of the dam and appurtenant facilities.

Geology

The regional and site geologic setting are critical in evaluating the adequacy of the site for a proposed dam. Additionally, the

seismic environment of the site will affect the design of the foundation and embankment of the dam. Landslides and potential landslides at the damsite or in the reservoir area must be considered in the design. Foundation conditions for the dam, spillway, and outlet works need to be determined in advance of final design. These can generally be resolved through review of geologic literature, geologic reconnaissance, and explorations.

Exploration and Testing for Foundations

If the site has numerous rock outcrops, and it is apparent by visual examination that the foundation will be bedrock with very little soil cover, subsurface investigation may not be required.

However, if the site has a thick soil cover, subsurface investigation will be required. A small tractor-mounted backhoe is often used for this work if the depth of exploration does not exceed about 12 feet. Several trenches are usually dug along the alignment of the dam, spillway, and outlet works to determine the depth to adequate foundation for the proposed structure. The trenches should be examined and logged, located on a site map, and samples taken for laboratory classification testing. If the depth to adequate foundation exceeds about 12 feet, drilling will probably be required.

Foundation for Embankment

Classification testing for embankment foundations comprised of soils would include mechanical analysis, and liquid and plastic limits (ASTM D-2487).

If the strength of the soil overlying the bedrock is questionable, field density tests (ASTM D-1556) and compaction tests (ASTM D-698) should be performed at several depths so that the relative compaction can be determined to establish the adequacy of the foundation and the depth of excavation required.

Foundation for Outlet Works

The foundation for the outlet conduit should be investigated by at least two trenches to determine location and character of adequate base materials. If the foundation is bedrock, often no testing is required. If the foundation is weathered bedrock or soil, the same testing as required for an embankment foundation is necessary.

Foundation for Spillway

The investigation for a spillway in weathered or firm bedrock is primarily to determine if the foundation at design grade is erodible. Usually, a trench at the crest and one or two along the channel would be sufficient. If the foundation is not erodible, laboratory testing would not be required. However, if a concrete lining is required for erosion control, classification

testing should be done. If the strength of the foundation is questionable, tests should be made so that an index of its competence can be determined.

Embankment Materials

Several trenches or auger holes should be located in proposed borrow areas for each type of material to be used in the dam. The purposes of the investigation are to determine the quantity and engineering properties of each material. Classification tests and compaction tests are required.

Water

A considerable amount of water is normally required for construction of a dam. Wherever practicable, embankment materials should be moisture conditioned in the borrow areas. Additionally, haul roads should be watered, and additional watering is often required on the fill to provide optimum moisture requirements and to prevent drying of the surface materials during construction. Ideal construction time is usually late spring or early summer, after the runoff period but before the soil has lost natural moisture.

CHAPTER III
EMBANKMENT DESIGN

General

An earthfill dam of any size must be designed to be safe and stable during its entire life, including construction. The following design considerations indicate many of the requirements which must be met if safety is to be assured:

1. The slopes must be stable and resistant to deformation under all operating conditions, including rapid reservoir drawdown.
2. Seepage through the embankment and its abutments and foundation must be controlled so that piping and sloughing do not occur.
3. The embankment must be safe from overtopping by both flood inflow and wave action.
4. The embankment must be safe from catastrophic failure during reasonably expectable earthquakes at the site.
5. The slopes must be safe from excessive damage from wave action or rain.

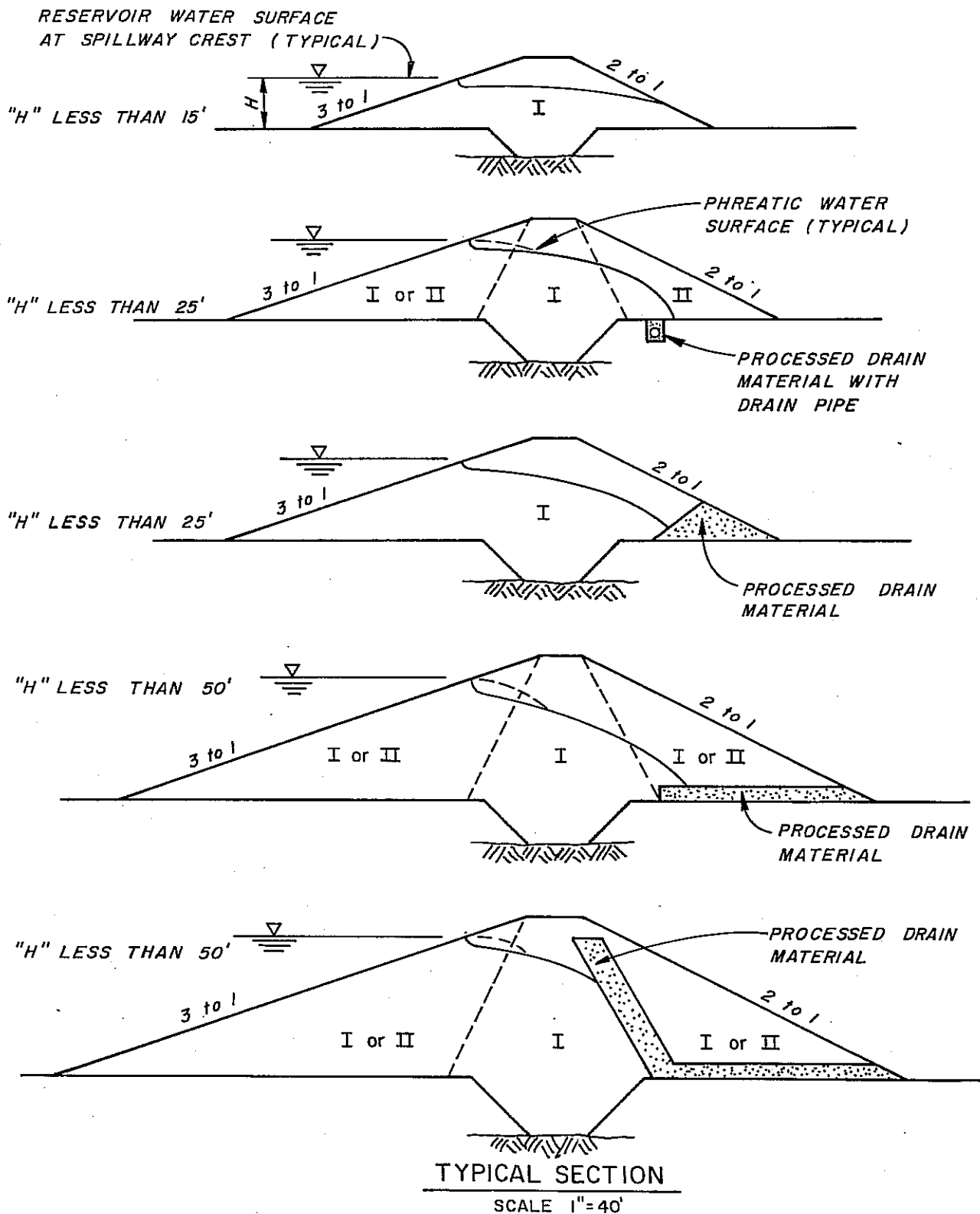
A small earthfill dam designed to meet the above criteria should prove to be safe, provided proper construction methods and control are achieved.

The embankment for this type of dam is normally constructed of native materials from the immediate vicinity of the dam. The materials are first moisture conditioned and then hauled to the dam by scraper or truck. A bulldozer is usually used to spread the material in loose lifts about 8 inches thick, and each lift is thoroughly compacted by a tractor-drawn sheepsfoot roller or a power-operated tamping roller.

These guidelines are considered applicable to foundations that can be determined to be suitable by visual inspection or by density and gradation tests. Such foundations may consist either of fairly dense soils, or of fresh or weathered bedrock. The foundation can be impervious soil or bedrock, or pervious soils with a cutoff trench.

Design Features

Embankment materials vary widely from site to site, particularly in respect to gradation and permeability. If the difference in permeability between the core and the downstream shell is great, no internal drainage is required. If the variation of the permeability between the core and shell is not sufficient, the dam will become nearly completely saturated after prolonged storage, and the downstream slope will show seepage to a height of approximately one-third the depth of the reservoir. Such saturation reduces the stability of the dam and creates maintenance problems. Major maintenance problems are (1) growth



LEGEND

- I - IMPERVIOUS
- II - SEMI-IMPERVIOUS TO PERVIOUS

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INTERNAL DRAINAGE METHODS

of undesired vegetation, and (2) minor sloughing from human and animal traffic. To eliminate such problems in dams where the downstream shell is relatively impervious, the Division requires the construction of internal drains on all but the smallest dams. In this type of design, small amounts of strategically placed pervious materials control the seepage and saturation. Patterns of internal seepage, as related to possible internal drains, are shown on Figure 1.

To obtain some of the advantages of a zoned dam, the coarser more pervious embankment materials, when available, should be placed in zones at the outer slopes (shells) and the finer more impervious embankment materials placed in the central portion of the dam (core).

If enough native pervious materials, such as sand and sand-gravel mixtures are available to construct a substantial downstream pervious zone, internal drainage is not required. Usually, if not more than 5 percent of the material is finer than the No. 200 sieve, the material can be considered pervious. The embankment impervious core must have a width at its base equal to at least one-half the height of the dam, or a minimum of 14 feet.

The slopes for most embankments on strong foundations can be 3:1 upstream and 2:1 downstream. However, flatter slopes should be considered for dams constructed on inorganic clay or high

plasticity and very fine inorganic silt. Organic soils are not usable as embankment materials.

The embankment soil must be compacted, based on ASTM D-698, to an average relative compaction of 97 percent in low seismic areas and 100 percent in high seismic areas. This degree of compaction can generally be achieved with soils having moisture contents near optimum, utilizing 6-inch compacted lifts, and requiring the number of roller passes as follows:

<u>Weight of Tamping Roller #/Lin. Ft.</u>	<u>Low Seismic Area</u>	<u>High Seismic Area</u>
2,500	12	14
3,000	10	12
3,500	9	11
4,000	8	10

Where drain material is required, in most cases it will have to be a processed material purchased from an aggregate supplier. Pit run borrow is usually too dirty. The following gradation, which conforms to the 1 1/2-inch concrete aggregate specified in Section 90-3.04 of January 1988 Standard Specifications, California State Department of Transportation, has given satisfactory results:

<u>Sieve Size</u>	<u>Percentage Passing</u>
1-1/2	90-100
3/4	45-75
4	30-45
50	4-10
100	1-3
200	0-2

However, the suitability of the drain material must meet the following criteria:

1. $\frac{\text{D15 of the drain}}{\text{D15 of the adjacent material}} = 5 \text{ to } 40$
2. $\frac{\text{D15 of the drain}}{\text{D85 of the adjacent material}} = 5 \text{ or less}$
3. $\frac{\text{D85 of the drain}}{\text{Diameter of hole in perforated pipe}} = 2 \text{ or more}$

Toe drains incorporating a drain pipe are often installed along the downstream toe of dams in conjunction with a drainage blanket, for the purpose of collecting seepage waters from the foundation and embankment. Drain pipes are also used at other locations for controlling seepage, such as under spillway linings. Because of corrosion and strength considerations, the following are the only types of drainpipes allowed: concrete, asbestos-cement, clay, and plastic (PVC).

The minimum embankment crest width shall be 12 feet. The minimum freeboard is 4 feet.

Surface drainage of the crest must be provided by sloping the crest 3 percent toward the reservoir. A camber of about 1 foot should normally be provided at the maximum section of the dam.

The need for riprap or other types of upstream slope protection must usually be determined on a case-by-case evaluation, although many small dams with small reservoirs and constructed of cohesive

soils have performed well with no slope protection. Most of the dams of this size will not need downstream slope protection other than a good grass cover.

Embankment Design on Bedrock Foundations

In almost all cases, a bedrock foundation will require very little treatment or consideration in respect to stability. Some bedrock foundations may have a moderate amount of seepage, but usually this is an economic and not a safety consideration. The usual treatment consists of stripping the loose soil mantle and vegetation to weathered bedrock having a strength greater than the embankment materials. Foundation cleanup can be accomplished by a dozer or scraper. Discing and watering may be required to bond the foundation with the embankment material. Under the central portion of the dam section, a cutoff trench with a width equal to one-half the height of the dam, or a minimum of 14 feet, should be excavated to firm bedrock to form an impervious cutoff. Cleanup will require considerable hand work and may require air blowing. The cutoff should extend up the abutments to the elevation of the maximum water surface.

In seismically active regions, no special foundation treatment is usually required for small dams other than determining whether an active fault is located under the dam or reservoir. An active fault in the reservoir, under or adjacent to the dam would

generally preclude construction of a dam without extensive design and construction requirements.

Embankment Design on Soil Foundations

Soil foundations should have strength properties equal to or greater than that of the embankment. To provide an objective basis for judgment, this would generally require that several in-place density tests and accompanying compaction test curves would have to be made, as discussed in Chapter II. The average relative compaction of foundation soils should be 97 percent of ASTM D-698 in low seismic areas, and 100 percent of this standard in high seismic areas. The entire area to be occupied by the dam should be stripped to a sufficient depth to remove all unsuitable materials, including surface boulders, loose rock, debris, topsoil, and vegetation, that might interfere with the proper bonding of the embankment with the foundation.

Under the central portion of the dam section, a cutoff trench must be provided. The cutoff should have side slopes no steeper than 1:1 for depths up to about 12 feet, and no steeper than 1-1/2:1 for greater depths. The bottom width of the trench should be equal to one-half the height of the dam, or a minimum of 14 feet. The depth of the cutoff would generally extend to bedrock, or to an impervious strata of soil that can be determined to be of sufficient extent as to prevent excessive seepage beneath the dam. Prior to placing embankment material,

the cutoff trench should be unwatered and should be cleaned of all loose, soft and disintergrated materials. Design of dams on pervious soil foundations, where a cutoff to bedrock or to an impervious soil strata cannot be achieved, are beyond the scope of these guidelines. Also, those foundations with densities less than indicated above represent special conditions outside the scope of these guidelines.

CHAPTER IV

SPILLWAY

Location

The spillway should be located sufficiently apart from the dam to prevent erosion of the dam embankment. The best location is in a saddle or cut completely isolated from the dam. Most dams have the spillway located adjacent to the dam, with a bedrock barrier between the dam and spillway. A spillway over the dam embankment is not acceptable.

Spillway Design Flood

For a small dam and reservoir where the downstream hazard from dam failure is minor, the minimum spillway design flood should have a return period of at least 1,000 years.

Freeboard

Minimum freeboard (vertical distance from spillway crest to dam crest) is 4 feet. Minimum residual freeboard (distance from maximum reservoir stage for spillway design flood and dam crest) is 1.5 feet.

Hydraulics

For the spillway design flood, the spillway walls in the vicinity of the dam must maintain the same residual freeboard as required for the dam. The downstream chute of the spillway must not be

over-topped for this flood. The rating curve for the spillway and the reservoir area-capacity curve should be shown on the drawings.

Design Considerations

In rock, where the erosion due to spillway flows will be minor to nil, the spillway can be a natural or an excavated channel.

In rock, where erosion may be minor to moderate, the spillway can be excavated channel with a concrete control sill at the entrance to the spillway. As erosion occurs, concrete and/or rock protection will be required.

When the spillway is to be located on soil or deeply weathered rock, the entire length of the spillway should be concrete or gunite lined. The average relative compaction of the foundation should be at least 97 percent of ASTM D-698. A stilling basin, flipbucket, or other type protection may be required to prevent erosion at the terminal end of the spillway.

Structural

Concrete design should be in accordance with the latest edition of the Building Code Requirements for Reinforced Concrete (ACI 318). Working stresses and ultimate strength designs should be based on a 28-day concrete strength of at least 3,000 psi.

Reinforced masonry design should be based on the latest edition

of the Uniform Building Code. Reinforcing steel should conform to ASTM 615. Structural steel design should be based on the latest edition of the AISC specifications.

The minimum thickness of all formed walls utilizing a single layer of reinforcing steel should be 6 inches. In addition, consideration should be given to the height of wall and the placement of concrete, therein, in setting the minimum wall thickness.

Cutoff walls and concrete control sills should have a minimum thickness of 12 inches. Concrete control sills should have a minimum depth of 3 feet in soils or weathered rock.

All concrete walls and slabs 10 inches or more in thickness should have two layers of reinforcing steel.

For concrete walls, including cutoff walls and concrete control sills, the minimum area of horizontal steel should be not less than .0025 and that of vertical steel not less than .0015 times the cross-sectional area of the wall.

The minimum steel area for floors, slabs, and footings should be .0020 times the cross-sectional area of the section.

All structures must be designed for the most severe load combinations anticipated. Seismic loadings need not be considered to act concurrently with storm water discharges. Buoyancy should be checked for U-shaped inlet structures. Earth loadings should be assumed on the basis of equivalent fluid pressures, based on cohesionless soil, as given by Rankine. No vertical walls (vertical walls being defined as any wall steeper than the angle of repose of the backfill material) should be designed for an equivalent fluid pressure of less than 30#/ft². Due to the possibility of the earth backfill being pulled away from the wall during dry periods, all vertical walls should be designed for internal hydrostatic loadings, as well as external loadings.

Wall footings should be safeguarded against frost heaving, and wall panels should be articulated to provide for adjustments in the event of foundation yielding or unequal settlement.

Spillway channel linings, where required, can consist of several types, with concrete and air-blown mortar being the most common. The absolute minimum thickness of a concrete lining should be 4 inches. Both lining types should be reinforced with 0.2 percent reinforcing bars or wire mesh in each direction. Depending on the foundation materials, underdrains may be required to prevent uplift pressures. Contraction joints should be installed at

intervals of 10 to 50 feet, depending on the lining thickness, reinforcing steel, and the subgrade materials.

Asphaltic concrete is not allowed for spillway channel linings.

CHAPTER V

OUTLETS

General

A low level outlet is required for emptying or lowering the reservoir in case of emergency; for inspection and maintenance of the dam, reservoir, and appurtenances; and for releasing waters to meet downstream water rights.

Location

The outlet conduit should be located near the base of one of the abutments on native competent material, preferably bedrock. The average relative compaction, if the foundation material is weathered bedrock or soil, should be at least 97 percent of ASTM D-698. The entire length of the conduit should be bedded on foundation materials of uniform density and consistency. If this is not possible, then the conduit should have the capability of deforming without cracking under differential settlement. This can be accomplished by using short lengths of conduit sections with articulated joints.

The final alignment of the outlet conduit should be determined in the field after site stripping operations, and after the embankment cutoff trench is excavated. Curved alignments and changes in grade may be desirable or necessary to locate the conduit on the most competent materials.

The outlet conduit should be positioned such that the full reservoir capacity, except for a small silt storage volume, can be discharged by gravity. In all cases it should be able to drain at least two-thirds the volume of the reservoir.

Capacity

Outlet conduits should be sized such that, as a minimum, one-half the reservoir capacity can be discharged by gravity in a period of seven days. The absolute minimum diameter of the conduit is 12 inches.

Controls

Outlet conduits must have an upstream control device (gate or valve) capable of controlling the discharge through all ranges of flow. A trashrack in front of this control is required. The trashrack bars and supports should be designed for a minimum of 25 percent of the reservoir head to which they would be subjected if completely clogged. An air vent pipe is required just downstream of the control gate. An outlet conduit which is connected directly to a distribution system should have a blow-off valve at or near the downstream toe of the dam.

Conduit

Only two types of outlet conduits are allowed -- precast reinforced concrete and cast-in-place reinforced concrete.

The precast pipe should have a reinforced concrete bedding and should be backfilled with concrete up to the pipe springline.

Both types of conduits should be installed or constructed in a trench. The bottom of the conduit trench should be at or lower than the bottom of the dam embankment cutoff trench at the point where the two cross. Constructing a conduit that bridges the cutoff trench is not allowed.

Cast-in-place conduits should be reinforced with at least 0.2 percent reinforcing steel, both longitudinally and transversely as hoops.

The minimum thickness of concrete should be 8 inches.

Expansion joints in the outlet conduit, spaced at a maximum of 32 feet, are required for compressible foundations.

Design

All outlet conduits should be designed for internal pressure equal to the full reservoir head and for superimposed embankment loads, acting separately. Embankment loads should be computed in accordance with Marston's Theory. Internal liners of cast-in-place conduits should not be considered as adding structural strength unless concrete liners are used.

CHAPTER VI

GUIDE SPECIFICATIONS

General

These guide specifications describe the various technical items of work pertaining to a fairly typical small embankment dam founded on acceptably strong soil and with a cutoff trench to weathered bedrock. Requirements for a typical spillway and outlet works are also given. Omitted are the general and special provisions usually included in a set of specifications and other work the owner may want included in the contract.

The guide specifications are written without any pay items of work. The assumption has been made for this size of project that the work would best be accomplished on a lump-sum basis. This does not preclude the owner from establishing pay items as he believes appropriate.

It should be understood that these guide specifications are strictly applicable only to the particular dam assumed for this example, and that the specifications for any other specific dam would, of necessity, require modifications, varying from minor to major, to suit the unique requirements met at each separate damsite.

GUIDE SPECIFICATIONS

1. Control and Diversion of Water
2. Clearing
3. Grubbing
4. Excavation
5. Cutoff Trench Foundation Preparation
6. Embankment
7. Underdrains
8. Riprap
9. Concrete Structures
10. Outlet Pipe
11. Gates and Appurtenances

1. Control and Diversion of Water

(a) General

The contractor shall furnish or procure all materials and labor required for constructing and maintaining all necessary cofferdams, channels, flumes, drains, sumps, and/or other temporary diversion and protective works and shall furnish, install, maintain, and operate all necessary pumping and other equipment for removal of water from the various parts of the work and for maintaining the foundations and other parts of the work free from water.

(b) Plan

Prior to beginning any work on the diversion and care of the stream and the removal of water from foundations, the contractor shall submit for the engineer's approval a water control plan showing his proposed method for the diversion and care of the stream during construction and removal of water from foundations and other parts of the work. Construction of the embankment and spillway must be completed by the first of November to prevent failure during construction due to overtopping of the embankment from flood.

2. Clearing

Areas to be cleared consist of the reservoir area, site of dam embankment, a 25-foot strip adjoining the downstream toe of the dam embankment, spillway area, and borrow and stockpile areas. Clearing shall consist of removal and disposal of all trees, brush, down timber, rubbish, and any existing fences.

3. Grubbing

The entire foundation area for the dam embankment and other structures and all portions of the borrow areas shall be grubbed. Grubbing of foundation areas shall consist of the removal of all stumps and roots 1-1/2 inches or more in diameter to a depth of 3 feet below natural ground surface. The borrow areas shall be grubbed to the extent necessary to obtain material free of stumps and roots.

4. Excavation

(a) General

All construction operations shall be so conducted as to avoid stream sedimentation in accordance with the requirements of the Water Resources Control Board and the Department of Fish and Game.

All excavation shall be carried to lines, grades, and dimensions shown on the drawings or established by the

engineer. During the progress of the work, it may be found necessary or desirable to vary the slopes or the dimensions of the excavation from those specified herein.

(b) Dam Embankment Foundation and Cutoff Trench

The entire area to be occupied by the foundation of the dam shall be stripped to material having strength parameters equal to or greater than those required of the embankment material.

The cutoff shall be excavated to impervious, moderately weathered rock.

(c) Spillway

Excavation for spillway includes all excavation required for the approach channel, spillway crest, and spillway discharge channel.

(d) Concrete Structure Foundations

The foundations for all concrete structures shall be excavated to firm weathered bedrock. Overexcavation shall be replaced with concrete backfill as specified in Section 9(e)(2).

(e) Outlet Conduit Trench

The trench in which the conduit is to be laid or constructed shall be carefully excavated to the established lines and grades shown on the drawings, or as revised and approved by the engineer, to provide a firm, uniform, and unyielding foundation for the entire length of the conduit. The alignment and grade of the outlet conduit shall be selected so as to cross the embankment cutoff trench at or below the trench bottom. If the characteristics of the foundation at any point are such that they might cause unequal settlement or provide unequal bearing or are otherwise unsuitable for a foundation, then the unsatisfactory materials shall be removed to such depth as may be directed by the engineer. The unsuitable materials shall be replaced with backfill concrete as specified in Section 9(e)(2).

(f) Utilization of Excavated Materials

It is the intent of these specifications that all required excavation suitable for embankment shall be utilized in the permanent construction. Suitable materials shall be excavated separately from the materials to be wasted. The suitable materials shall be segregated by loads during the excavation operations and shall be placed in the designated final locations directly from excavation. Excavated materials, if any,

which are unsuitable for, or in excess of, dam embankment or other construction requirements, shall be disposed of within the vicinity as directed. Waste areas shall be left reasonably smooth and shall be sloped to drain.

(g) Borrow Excavation

Except for utilization of material obtained from required excavation as herein specified and shown on the drawings, all material necessary for construction of required embankments shall be obtained from the borrow area shown on the drawings within the reservoir site. The method of excavation in the borrow area shall be subject to the approval of the engineer.

Borrow areas shall be stripped of all topsoil containing humus, roots, rubbish, and other materials not suitable for placing in the compacted fill. The sequence of stripping operations shall be coordinated with the excavation and fill so as to effect required moisture control with minimum addition of moisture to the excavated material.

Unsuitable material encountered in the borrow areas shall be wasted as directed by the engineer. The surface of all waste areas shall be left in a

reasonably smooth condition and shall be sloped to drain.

5. Cutoff Trench Foundation Preparation

(a) General

The cutoff trench shall have a bottom width of not less than 14 feet, and shall be excavated to the approximate depth and at the location shown on the drawings. The exact depth will be determined by the nature of the materials encountered. The foundation of the cutoff trench shall consist of firm, impermeable, in-place, weathered rock.

(b) Cleanup

All loose rock fragments, dirt, gravel, standing or running water, and other objectionable materials shall be removed from the surface of the entire area of the cutoff trench foundations, by hand if necessary, to the extent directed by the engineer. Open cracks or joints shall be filled with backfill concrete or grout after removing soft or erodible crack-filling materials to a depth directed by the engineer. No fill shall be placed in the trench until the area to be covered has been inspected and approved by the engineer and by duly designated representatives of the Department of Water Resources, Division of Safety of Dams.

6. Embankment

(a) Requirements

Embankments shall be constructed to the lines and grades and cross sections indicated on the drawings, unless otherwise directed by the engineer. The contractor shall maintain and protect the embankment in a satisfactory condition at all times until final completion and acceptance of all work.

Any material placed in the embankment which fails to meet the requirements of the specifications, or which may have been placed or compacted at times or in a manner not acceptable to the engineer, shall be removed and disposed of or replaced properly at no cost to the owner.

(b) Materials

Embankments are to be constructed of suitable earth or rock materials obtained from borrow areas, cutoff trench, spillway and other required excavations. It is the intention of these specifications to use the most suitable materials obtainable from these sources without special processing. Materials containing brush, root, sod, or other perishable materials will not be considered suitable. The suitability of materials shall be subject to approval, and the

disposition of materials in the embankment will be as directed by the engineer. The contractor shall excavate at the locations directed by the engineer whenever such control is necessary to obtain the type of material required for the embankment. Blending of materials by the excavation process in the borrow area may be required.

(c) Foundation Preparation

After clearing and stripping has been completed as specified, earth foundations shall be prepared as follows:

The sides of stump holes, test pits, and other similar cavities or depressions shall be broken down, where so directed, so as to flatten out the slopes; and the sides of the cut or hole shall be scarified to provide bond between the foundation material and the fill where directed. Unless otherwise directed, each depression shall be filled with properly moisture-conditioned impervious materials. The fill shall be placed in layers and compacted in accordance with the applicable provisions of this section. Materials which cannot be compacted by roller equipment because of inadequate clearances shall be spread in 4-inch-thick layers and each layer shall be compacted with power tampers to the

required density of the contiguous compacted materials. After filling of depressions, and immediately prior to placement of compacted fill in the embankment, the embankment foundation, excluding the cutoff trench foundation and bedrock foundations, shall be scarified to a depth of 3 inches.

After removal of roots or other debris turned up in the process of scarification, the entire surface of the embankment foundation material shall be moisture conditioned and compacted in accordance with the applicable provisions of Sections 6(e) and (f).

(d) Placement

No fill shall be placed on any part of the embankment foundation until the area to be covered has been inspected and approved. The distribution of materials shall be such that the embankment will be free from lenses, pockets, streaks, and layers of material differing substantially in texture or gradation from the surrounding material. Materials shall be spread in layers of uniform thickness. Unless otherwise directed, the thickness of layers before compaction shall be not more than 8 inches. Compaction of each layer shall be conducted in a systematic and continuous manner so as to ensure the specified coverage.

Rolling shall be done parallel to the axis of the dam wherever possible. The embankment shall be brought up in layers such that the surface is essentially level at all times, except for a slight slope for drainage. In general, the more fine impervious materials shall be placed toward the center of the embankment, and the coarse more pervious materials toward the outer portion of the embankment. Materials placed in the cutoff trench and in the central portion of the dam shall have at least 15 percent of the material by weight passing the No. 200 sieve. No material larger than 6-inch maximum dimension will be permitted in an 8-inch layer, and each large piece shall be surrounded by fine material. Several large pieces in contact with each other will not be acceptable. Embankment construction shall be suspended when the ambient temperature drops below 32° F.

(e) Moisture Control

The fill material shall have a moisture content throughout each layer at time of compaction of from "optimum minus one percent" to "optimum plus two percent", as determined by ASTM D-698, Method A, unless otherwise directed. The contractor will be required to add water and manipulate the fill materials by harrowing or other approved methods so as to provide a

uniform distribution of moisture in the material within the limits specified above. The application of water to the fill material shall be done at the site of excavation or stockpile, and shall be supplemented, if necessary, by sprinkling on the embankment.

If, in the opinion of the engineer, the top or contact surfaces of a fill section become too dry or smooth to permit suitable bond between these surfaces and the additional fill to be placed thereon, it shall be moistened and/or worked with a harrow, scarifier, or other suitable equipment in an approved manner to a sufficient depth to provide satisfactory bonding before the next succeeding layer of earth fill material is placed.

(f) Compaction

When the moisture content and conditions of the embankment material are satisfactory, fill material shall be placed as previously specified and compacted by a minimum of eight passes of the specified sheepsfoot tamper roller or approved equivalent. Roller drums shall be no less than 60 inches in diameter and not less than 60 inches in length. The weight of the roller shall not be less than 4,000 pounds per linear foot of drum length. If, with the

required water content, it is found necessary to roll each 8-inch layer more than 8 times to obtain the required compaction, the number of passes shall be changed accordingly as directed by the engineer. However, the embankment fill shall be compacted to an average density of at least 97 percent, with no test less than 95 percent, as determined by ASTM D-698, Method A. Compaction by flooding or jetting will not be permitted.

(g) Finishing Embankments

After completion of the embankment, the slopes shall be dressed and graded so as to provide a uniform surface and slope. The crest shall be dressed and sloped for drainage as shown on the drawings.

(h) Structure Backfill

Backfill within 2 feet of structures shall be placed in layers not more than 4 inches in uncompacted thickness and no material larger than 3-inch maximum dimension will be permitted. Compaction shall be performed with the use of hand-held power tampers as approved by the engineer.

7. Underdrains

(a) General

The contractor shall furnish all materials and labor required for installing the drainage blanket, toe drain, drains, perforated underdrain pipes, and terminal pipe as shown on the drawings.

(b) Pipe

The kind of perforated pipe underdrain to be installed shall be at the option of the contractor, but shall consist of one of the following types (or other non-metallic types) as approved by the engineer:

Asbestos-Cement perforated underdrain pipe shall conform to ASTM C-508, Type II.

Perforated clay pipe shall conform to ASTM C-700, extra strength.

Perforated concrete pipe shall conform to ASTM C-444, Type I, and to ASTM C-14, Class I.

(c) Terminal Pipe

The terminal pipe shall be of the same material as the underdrain pipe, except that it shall not be perforated.

(d) Permeable Material

Permeable material for use in backfilling trenches; under, around, and over underdrains; and permeable material for drain blankets, riprap bedding, or other

subdrainage purposes shall consist of hard, durable, clean sand, gravel or crushed stone and shall be free from organic material, clay balls, or other deleterious substances.

The percentage composition by weight of permeable material in-place shall conform to the following gradings when determined by ASTM D-422:

<u>Sieve Size</u>	<u>Percentage Passing</u>
1 1/2 inch	90-100
3/4 inch	45-75
No. 4	30-45
No. 50	4-10
No. 100	1-3
No. 200	0-2

(e) Installing Underdrains

Trenches for underdrains shall be excavated, the pipe installed, and the trench backfilled with permeable material according to the dimensions and details shown on the drawings. Permeable drain material shall be placed and compacted thoroughly wet.

Perforated pipes shall be laid with the perforations down.

Permeable drain material shall be compacted in layers not exceeding eight inches by at least three passes of a heavy-duty, vibrating base-plate compactor weighing no less than 200 pounds, and having a vibration frequency of no less than 1,600 cycles per minute. Extreme care shall be exercised in compacting the permeable drain material so that the underdrain pipe is not damaged or dislocated. The compactor shall be subject to the approval of the engineer.

8. Riprap

(a) General

The contractor shall furnish all materials and labor required for placing riprap and bedding to the lines and dimensions as shown on the drawings.

(b) Quality

Individual rocks shall be dense, sound, and resistant to abrasion and shall be free from cracks, seams, and other defects that would tend to increase unduly their alteration by water and frost actions. The rocks may be either angular, as obtained from quarry operations, or round, except that round rocks shall not be placed on any surfaces having slopes steeper than 2:1. The rocks shall have a minimum bulk specific gravity of 2.4

(150 pounds per cubic foot) when tested in accordance with ASTM C-99.

(c) Gradation

Riprap shall be reasonably well graded, with at least 75 percent of the riprap by weight being equal to or larger than 75 pounds.

(d) Bedding

Bedding material shall conform to Section 7(d), "Permeable Material". Bedding material shall be compacted in layers not exceeding 10 inches in loose thickness by at least three coverages of the tread of a D8 tractor weighing at least 34,500 pounds. Bedding material within 5 feet of structures shall be compacted in layers not exceeding 6 inches in loose thickness by hand-held power tampers. Bedding material shall be placed and compacted thoroughly wet. The compaction and/or alternate methods of compaction shall be subject to the approval of the engineer.

(e) Installing Riprap

The riprap need not be compacted, but shall be placed to grade in a manner to ensure that the larger rock fragments are uniformly distributed, and the smaller rock fragments serve to fill the spaces between the

larger rock fragments so as to result in well-keyed, densely placed, uniform layers of riprap of the specified thickness. Hand placing will be required only to the extent necessary to secure the results specified above.

9. Concrete Structures

(a) The contractor shall furnish or procure all materials and labor required for constructing all the concrete structures, including the spillway sill and intake structure, to the lines and grades shown on the drawings. Excavation shall be as specified in Section 4(c), (d), and (e).

(b) Composition

Concrete shall meet the requirements of ASTM C-94 specifications.

(c) Cement

The cement used for all concrete structures shall be ASTM C-150, Portland Cement Type II.

(d) Aggregates

All concrete aggregate shall be from proven sources of materials not reactive to alkali or sulfates, with

maximum size particles passing 1½-inch-square opening.
Aggregates shall conform to ASTM C-33.

(e) Strength and Consistency

- (1) Structural Concrete -- minimum 28-day test, 3,000-pound-per-square-inch compression with 5-inch slump maximum.
- (2) Backfill Concrete -- shall contain not less than four 94-pound sacks of Type II Portland Cement per cubic yard of concrete and shall have only sufficient water to provide the necessary consistency for placing.

(f) Steel Reinforcement

Steel reinforcement shall consist of intermediate grade deformed bars, conforming to ASTM A-615, Grade 40.

Reinforcing steel shall be clean and free from heavy rust, scale, or coating of any kind and shall be held in place and tied at splices, corners, and intersections with 16-gauge annealed wire.

The spacing of bars, measured center to center, shall be as shown on the drawings or as directed by the engineer.

All splices in steel reinforcement shall provide an overlap of 24-bar-diameters or as shown on the drawings.

(g) Waterstop

Rubber or polyvinyl chloride waterstop shall be furnished and installed in the joints at the locations shown on the drawings. The contractor shall take suitable precautions to support and protect the waterstop during the progress of the work, and shall repair or replace any damaged waterstop. All waterstop shall be stored in as cool a place as practicable, preferably at 70° F. or less. Waterstop shall not be stored in the open, or where it will be exposed to the direct rays of the sun. All waterstop shall be subject to the approval of the engineer.

(h) Forms

Forms shall be true to line and grade, mortar tight, and sufficiently rigid to prevent bulging and deformation under load.

No forms shall be removed within four days of placing concrete, or without approval by the engineer, and all removal shall be accomplished in a manner which will prevent injury to the concrete.

(i) Transportation and Placing

Concrete shall be transported from the mixer to the forms as rapidly as possible by methods that will prevent segregation and loss of ingredients. Any concrete which, during transportation, has become too stiff for effective placement or consolidation shall be wasted. In no case shall concrete be used which has been retained in truck mixers for more than 90 minutes after the introduction of mixing water to the batch. Concrete retained in truck mixers for more than 45 minutes shall be continuously agitated.

Before placing concrete, the forms and steel reinforcement shall be approved for position, stability, and cleanliness. Concrete placement shall not commence until the engineer's approval has been obtained. All concrete shall be placed in the presence of the engineer. The concrete shall be deposited as nearly as possible in its final position. Drop chutes and elephant trunks shall be used on drops greater than 5 feet. Concrete shall be placed at such a rate that all concrete in the same lift will be deposited on plastic concrete. The concrete comprising each unit of work shall be placed in a continuous lift.

Concrete shall be transported from the mixer and placed within the forms within limits of time and by methods that will prevent segregation and loss of ingredients, so as to provide a dense and homogeneous mass, free from voids or rock pockets, and conforming to the lines and grades shown on the drawings.

All concrete shall be thoroughly compacted into place by use of approved immersion-type vibrators, supplemented by hand spading, rodding, and tamping, as necessary. The duration of vibration shall be limited to the minimum required to produce satisfactory consolidation without causing segregation. Vibrators shall not be used to promote horizontal movement of concrete within the forms.

(j) Finishing

Immediately after removal of forms, all unsightly ridges or lips shall be removed from permanently exposed surfaces. Defective concrete and concrete containing voids or rock pockets shall be removed and repaired as directed by the engineer. All permanently exposed concrete (other than formed faces) shall have wood float finish.

(k) Embedded Items

Before placing concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place in true alignment, as indicated on the drawings or as required. Embedded items shall be free of oil and other foreign matter, such as loose coatings of rust, paint, and scale.

(l) Curing and Protection

All concrete shall be moist cured by maintaining all surfaces continuously wet for a period of not less than 14 days after being placed by sprinkling or spraying or by other methods approved by the engineer. At the option of the contractor, and if approved, concrete may be cured with pigmented curing compound of the surface membrane type instead of water. Curing compound, if used, shall be applied and maintained in strict compliance with the manufacturer's recommendations.

All fresh concrete shall be adequately protected from damage by construction equipment.

10. Outlet Conduit

(a) General

The contractor shall furnish all materials and labor required for installing or placing the outlet conduit

to the lines and grades shown on the drawings. The outlet conduit shall be either precast reinforced concrete pipe or cast-in-place reinforced concrete pipe, at the contractor's option. However, only one type will be allowed throughout the work. Conduit trench excavation shall be as specified in Section 4(e), "Outlet Conduit Trench". Outlet conduit bedding and/or encasement concrete shall be placed in the trench without forming.

(b) Alignment

The conduit alignment shown on the drawings is only approximate. The final alignment is to be determined in the field after the embankment foundation has been stripped and after the cutoff trench has been excavated. The conduit shall be located on native, undisturbed, competent material, as determined by the engineer.

(c) Precast Reinforced Concrete Pipe

Precast reinforced concrete pipe shall be of the class shown on the drawings and shall conform to ASTM C-76. Cement shall conform to ASTM C-150, Type II. The pipe shall have a reinforced concrete bedding placed concurrently with or after the pipe is in position. The concrete shall be structural concrete and shall

conform to Section 9, "Concrete". The concrete shall extend up the sides of the pipe to the centerline of the pipe. The pipe shall be laid upgrade, unless otherwise permitted by the engineer.

Pipe joints shall have rubber gaskets conforming to ASTM C-443, and shall be flexible and able to withstand expansion, contraction, and settlement. Rubber gaskets shall be stored in as cool a place as practicable, preferably at 70° F. or less, and in no case shall the rubber gaskets be exposed to the direct rays of the sun for more than 72 hours.

(d) Cast-In-Place Pipe

Concrete for cast-in-place pipe shall be structural concrete and shall conform to the requirements of Section 9, "Concrete".

The liner, at the option of the contractor, shall be of one of the following types:

- (1) Corrugated metal pipe shall conform to the requirements of AASHO M-36, and shall be 16-gauge. Pipe sections shall be connected with standard field couplers 12 inches wide and of the same gauge as the pipe.

- (2) Welded steel pipe shall conform to the requirements of AWWA C-201 and shall be .135 inch in thickness. Steel shall be ASTM A-36.
- (3) Asbestos cement pipe shall conform to the requirements of ASTM C-428 and shall be Class 2400. Other types of pipes may be substituted, subject to the approval of the engineer. Only one type of pipe will be allowed in the work.

(e) Expansion Joints

Expansion joints shall be installed at the locations shown on the drawings and shall conform to ASTM D-994.

11. Gates and Appurtenances

(a) Gates

Gates are to be installed at the locations shown on the drawings.

Gates, lifts, and accessories shall be of the size, type, and construction shown on the drawings, and as specified herein. They shall be the product of one manufacturer regularly engaged in the manufacture of gates and accessories, such as Armco, Waterman Industries, or Rodney Hunt, etc.

The gates, lifts, and accessories shall operate properly for the use intended, with a practical degree of water-tightness and have seating heads equal to, or in excess of, the heads shown on the drawings. The seating head shall be the vertical distance from the centerline of the gate opening to the maximum water surface.

The gates shall have a flatback design, and bronze seats, rising stem, galvanized assembly bolts, galvanized anchor bolts, and galvanized frame.

(b) Gate Stem

The gate stems shall be naval bronze and cold rolled steel, as shown on the drawings, with cold drawn steel stem splices, as recommended by the manufacturer.

(c) Gate Lift

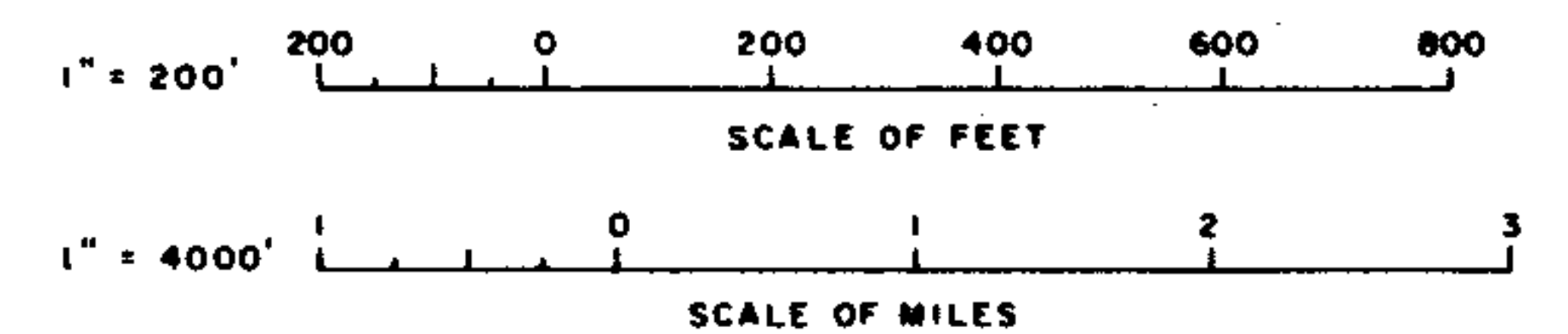
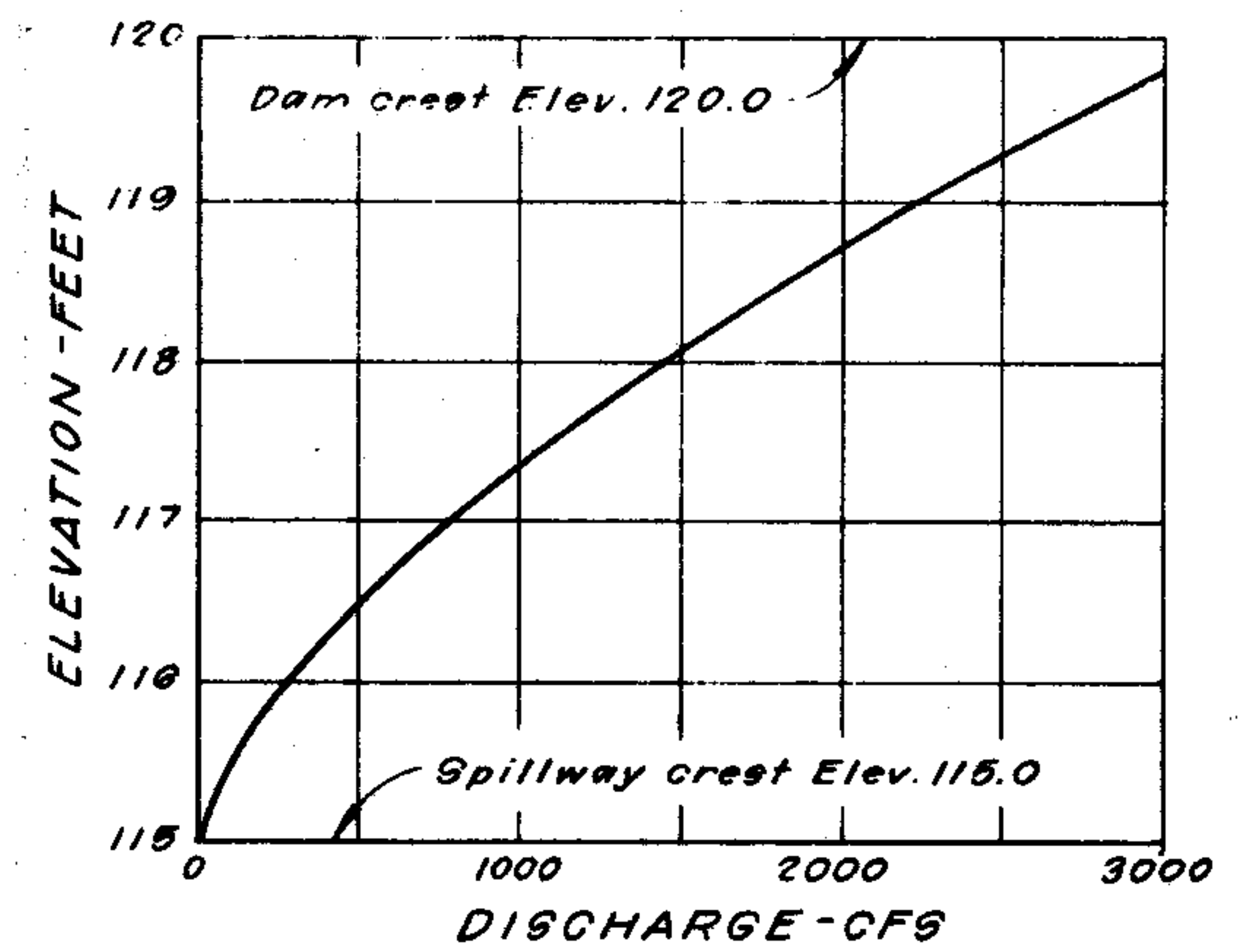
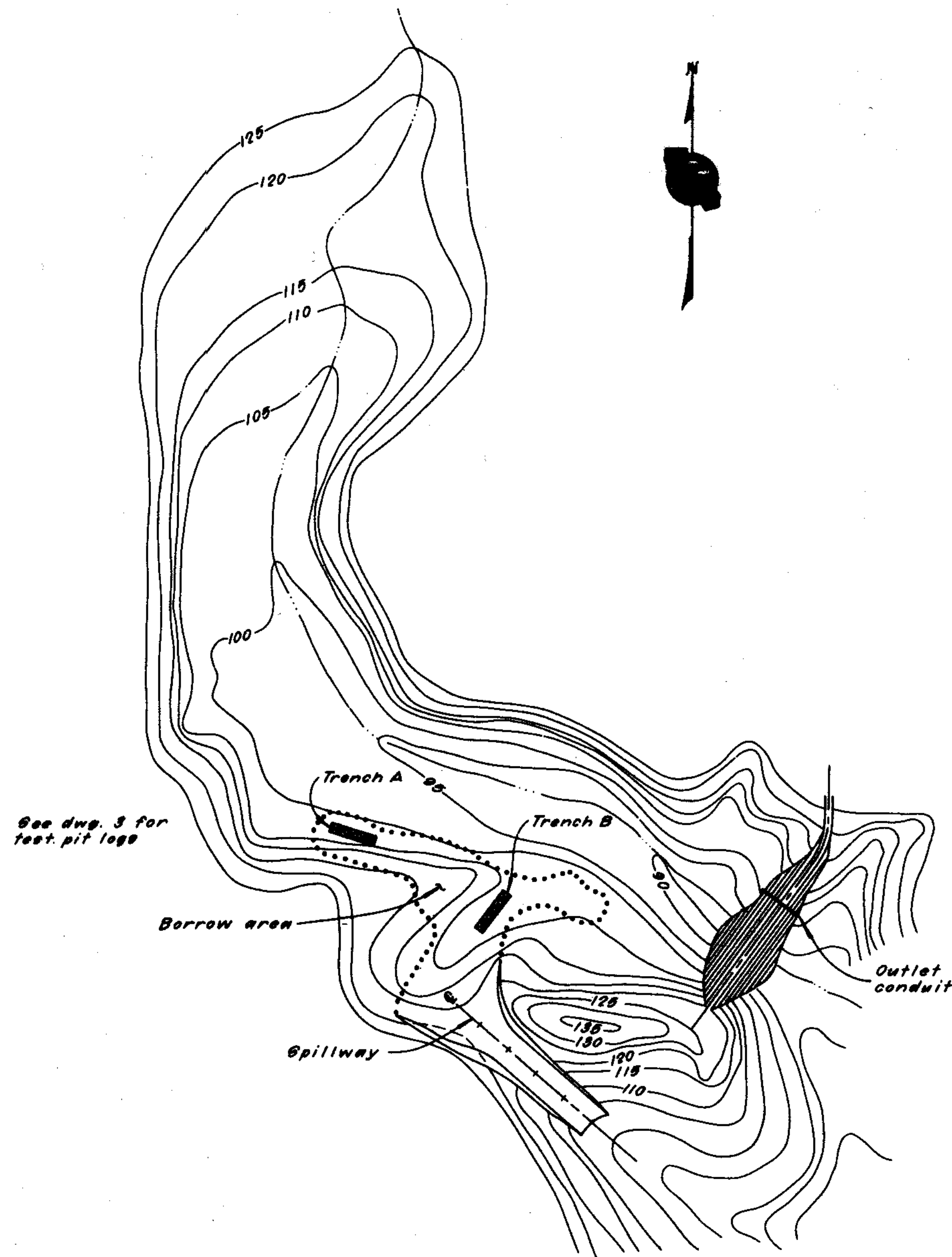
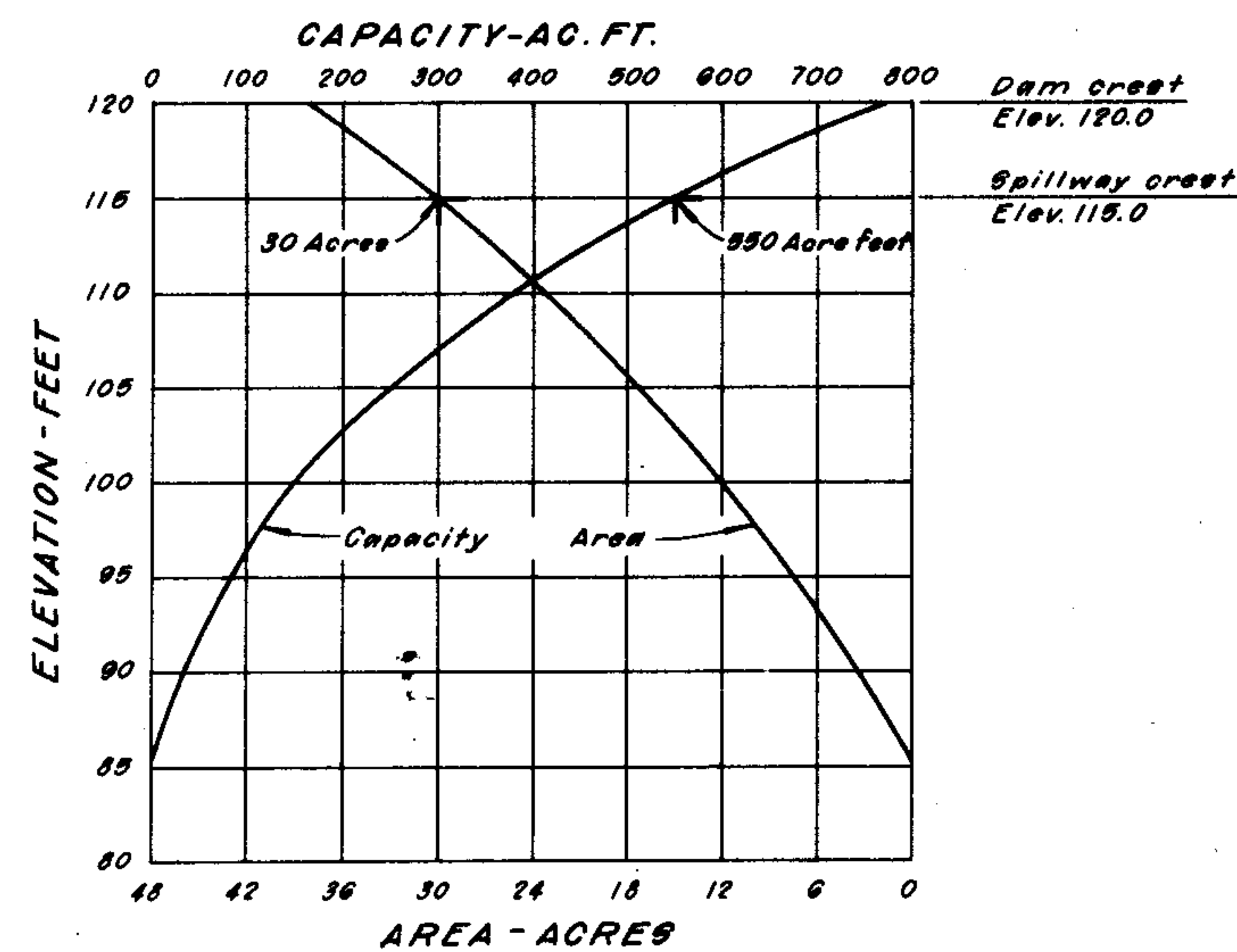
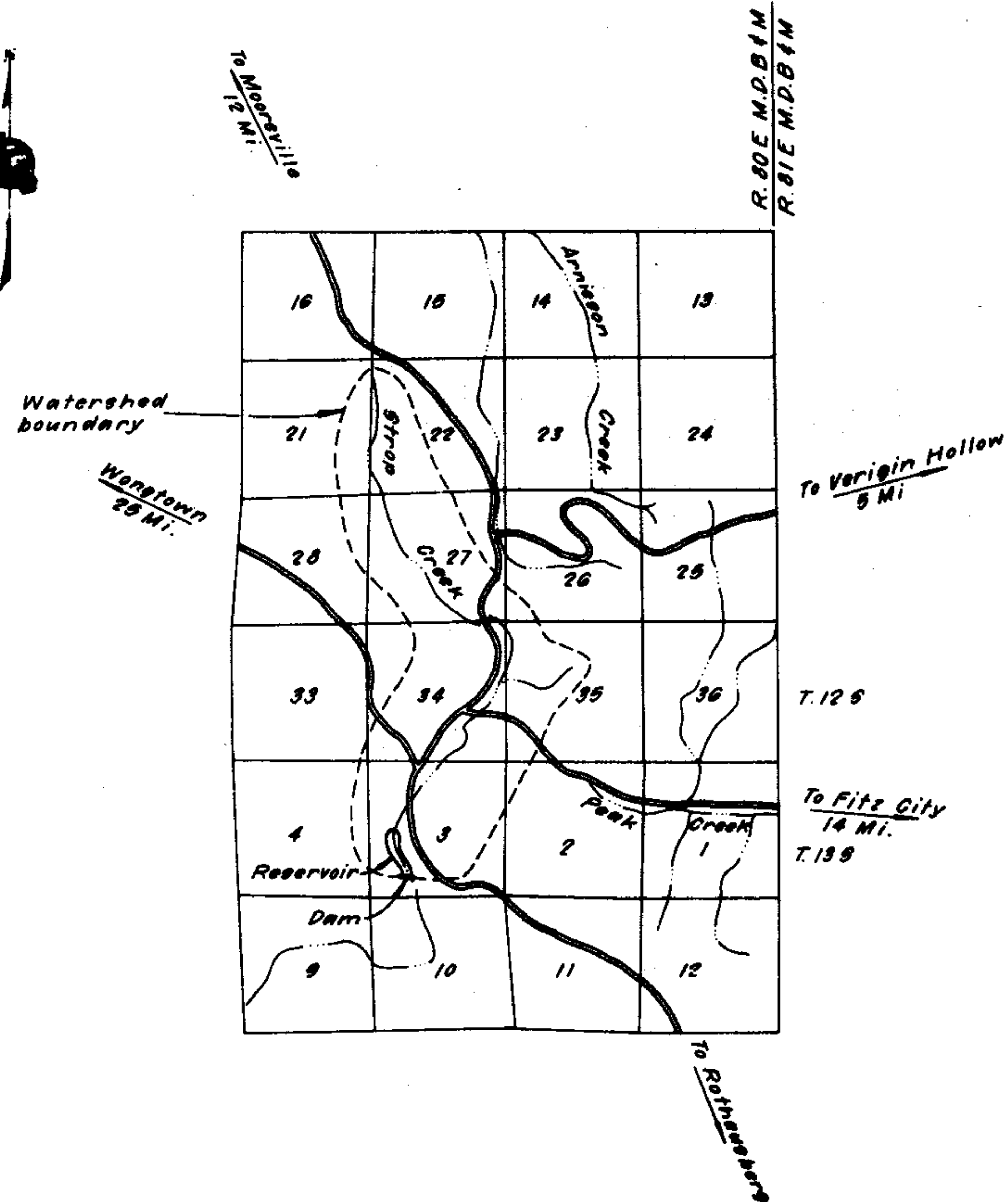
The gate lift shall be manually operated, and shall be sized to operate the gate with a pull of not more than 40 pounds, when raising or lowering the gate under maximum operating head. The lift nuts shall be bronze, and the anchor bolts shall be galvanized.

(d) Oil Seal

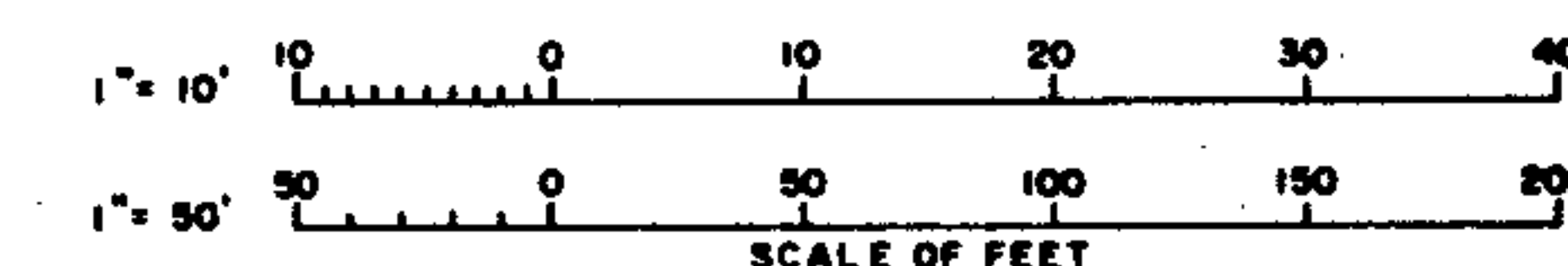
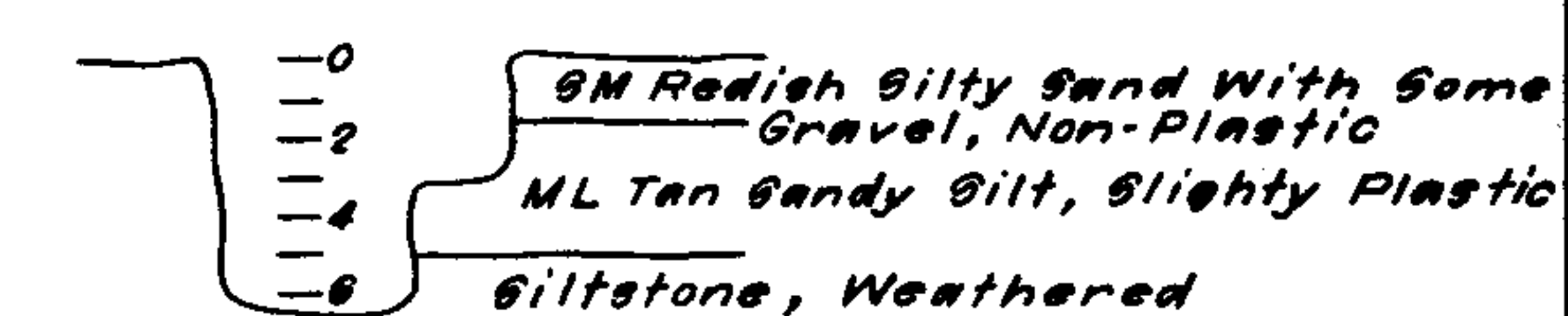
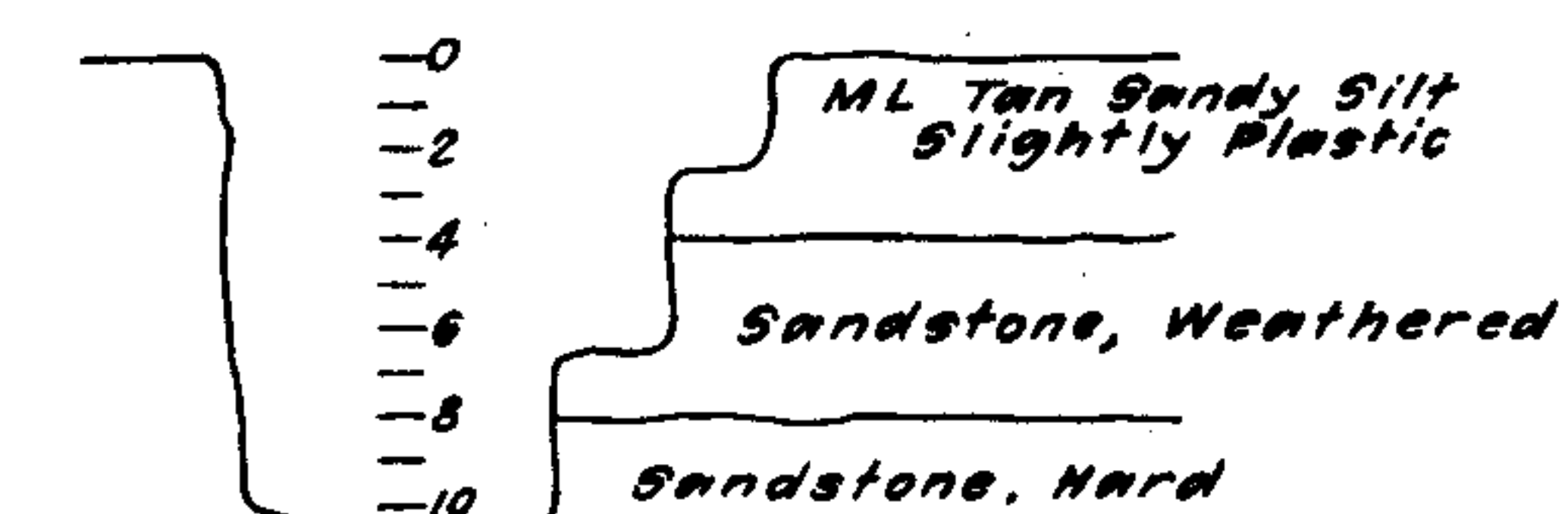
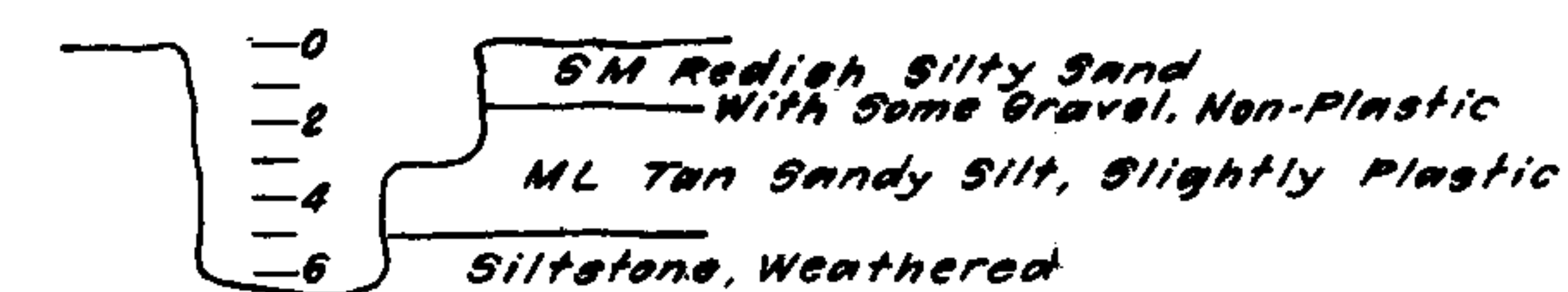
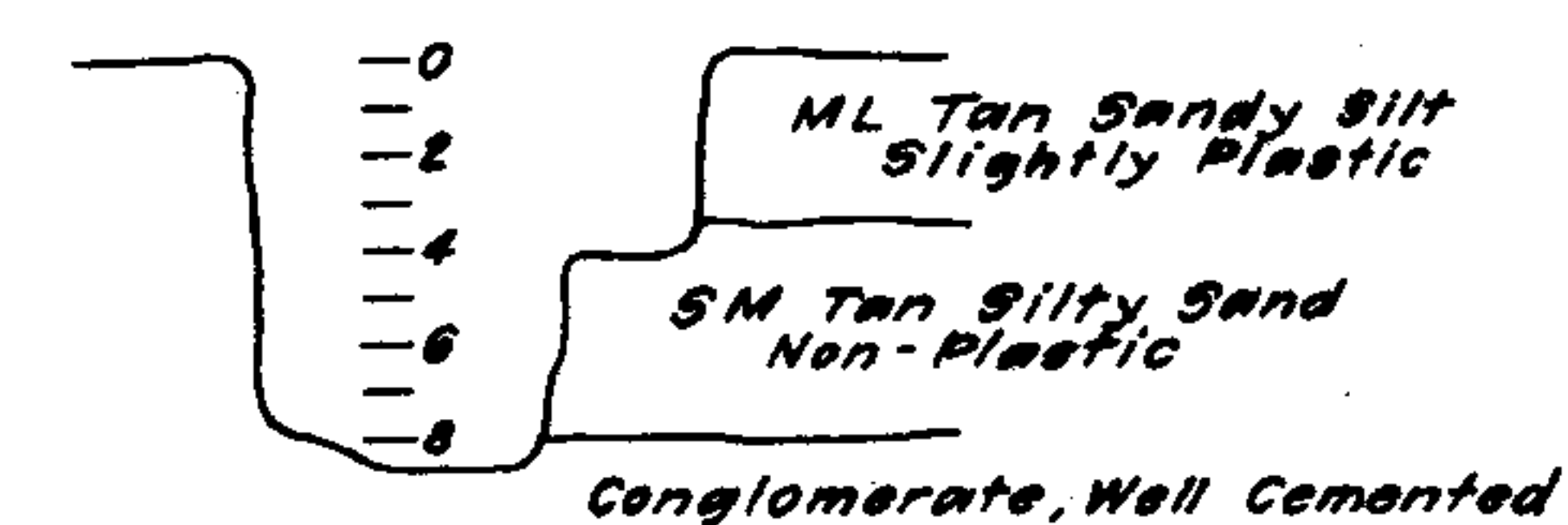
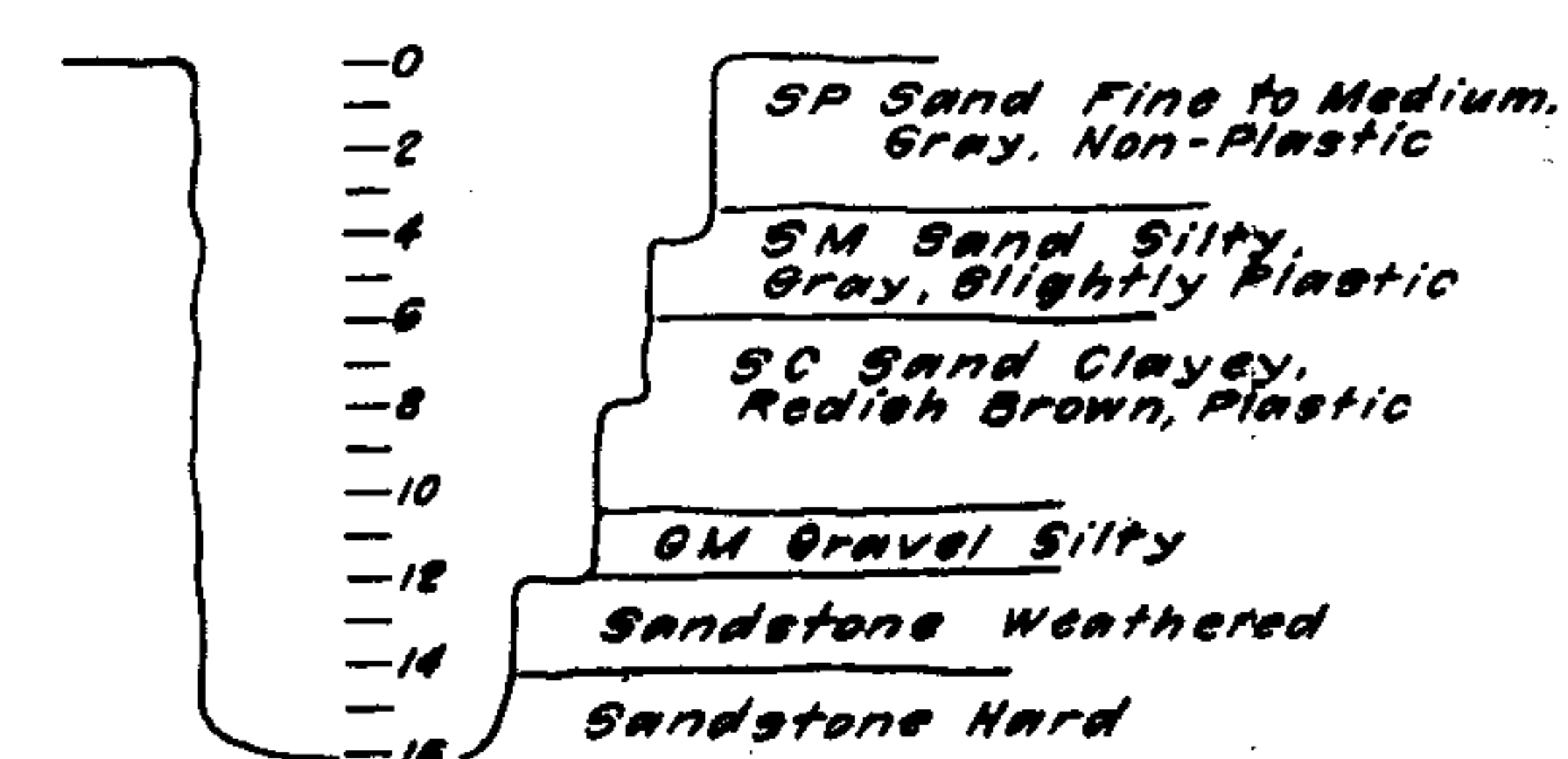
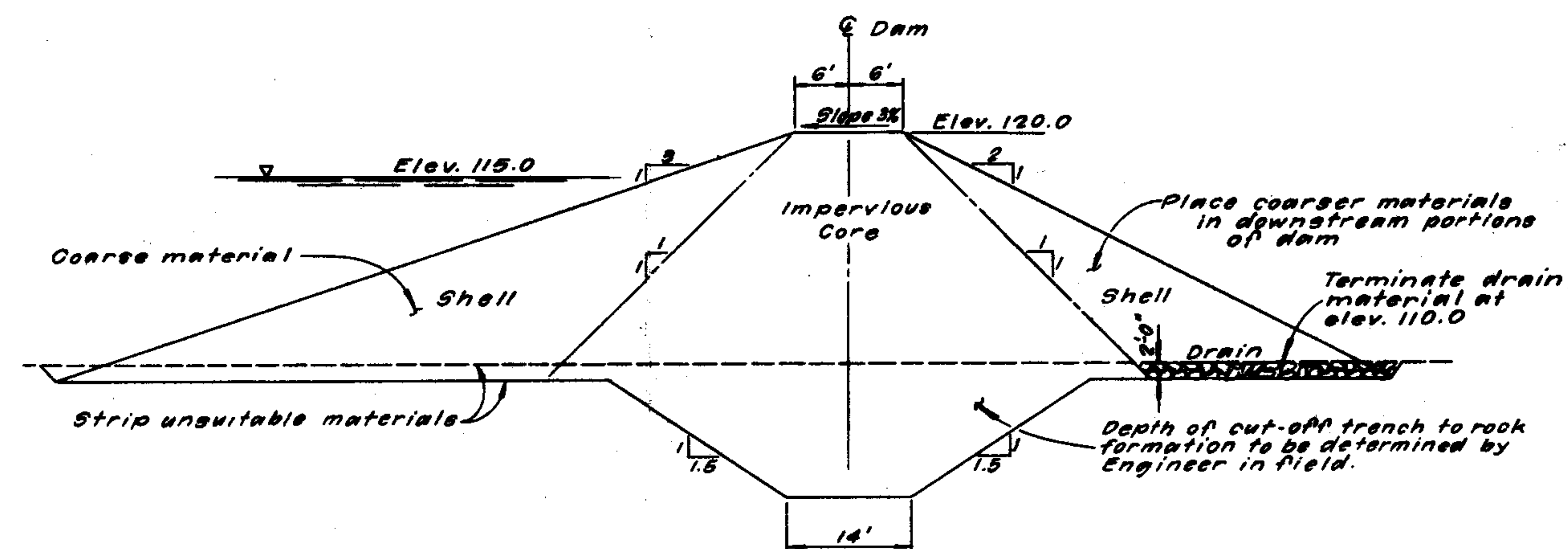
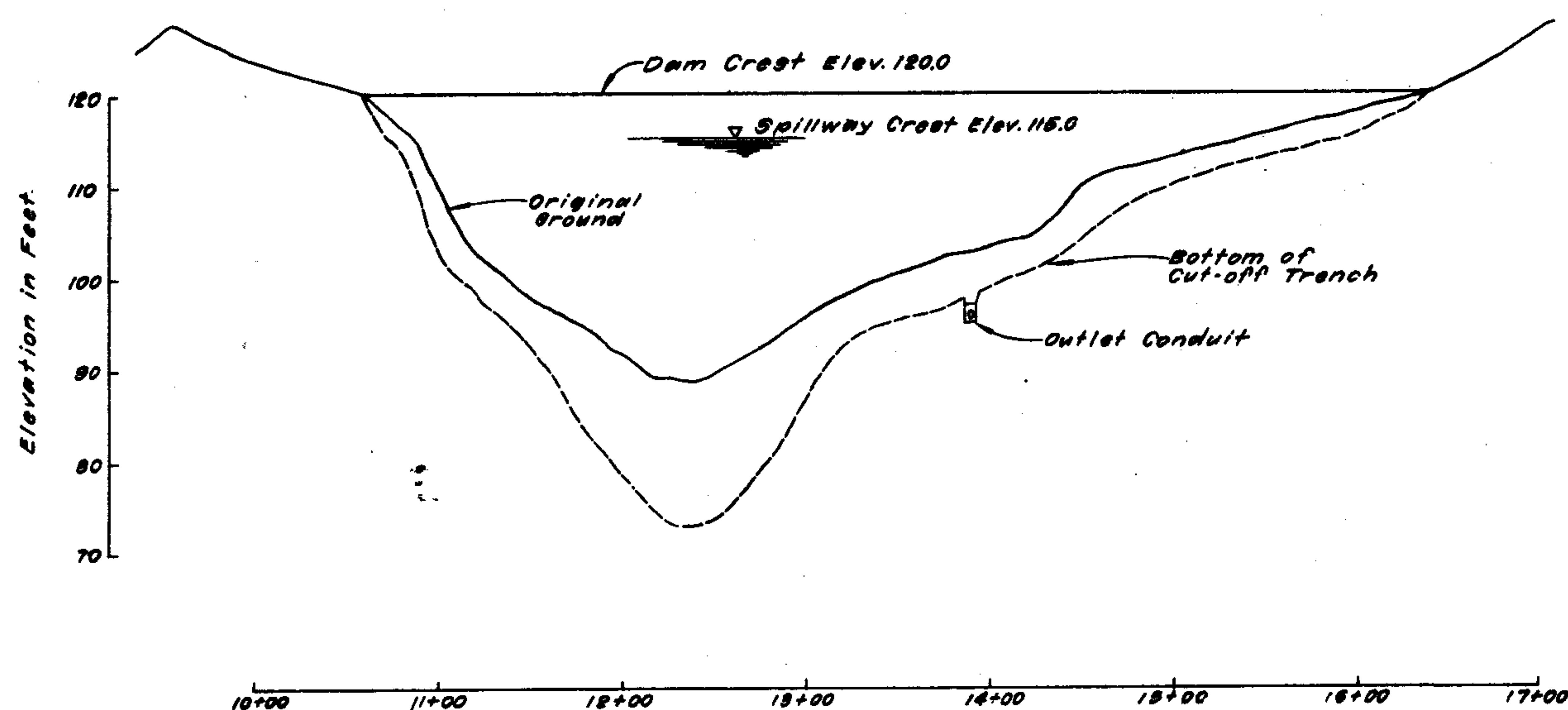
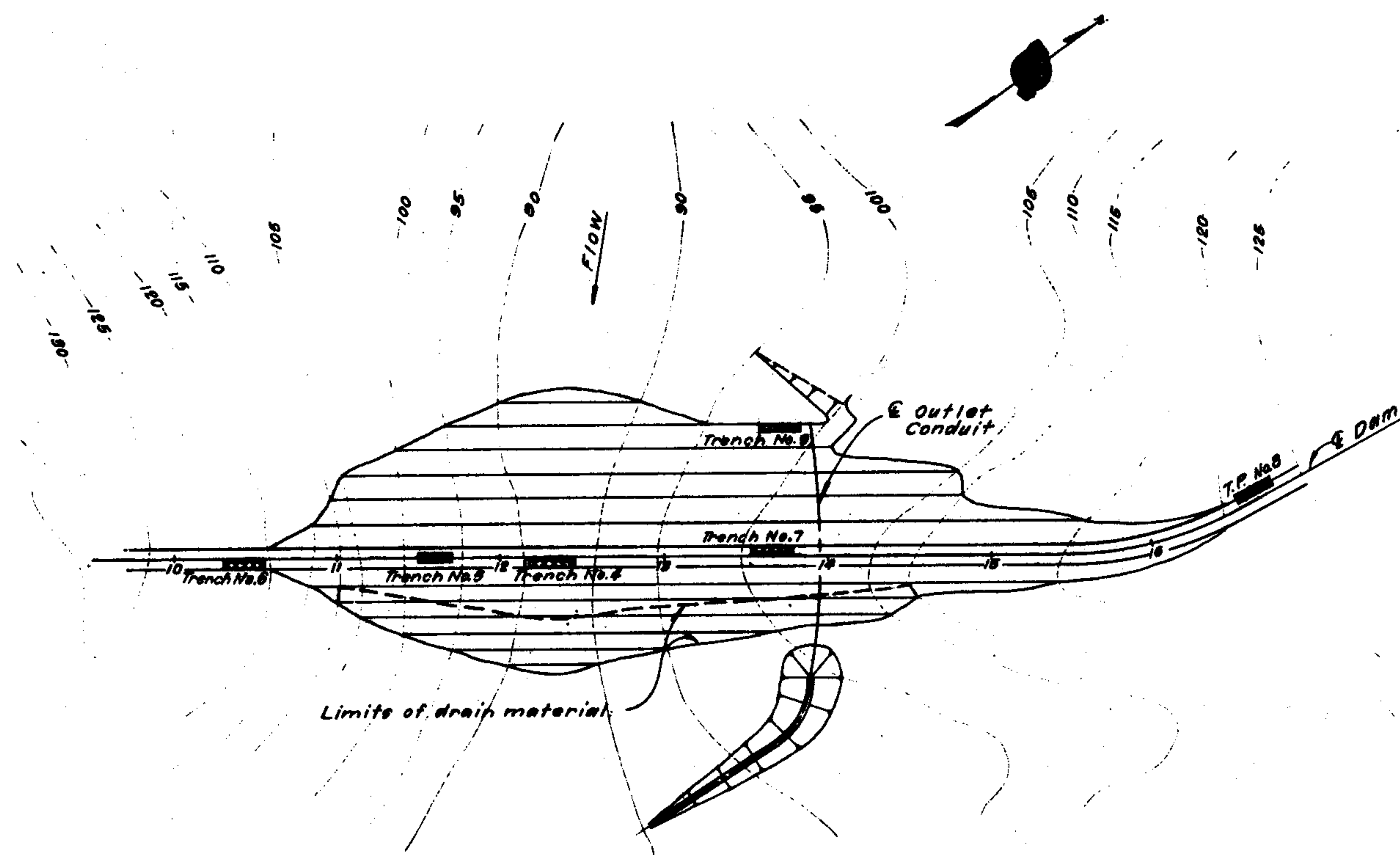
The oil seals shall be as recommended by the manufacturer.

(e) Trashrack

Trashracks shall consist of galvanized structural steel members, fabricated and installed in accordance with the details shown on the drawings. All structural steel shall conform to ASTM A-36. Bolts, washers, and nuts shall conform to ASTM A-307.



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STATE OF CALIFORNIA THE RESOURCES AGENCY DEPARTMENT OF WATER RESOURCES DIVISION OF SAFETY OF DAMS			
SWEETWATER DAM AND RESERVOIR			
DAM AND RESERVOIR			
LOCATION AND GENERAL PLAN			
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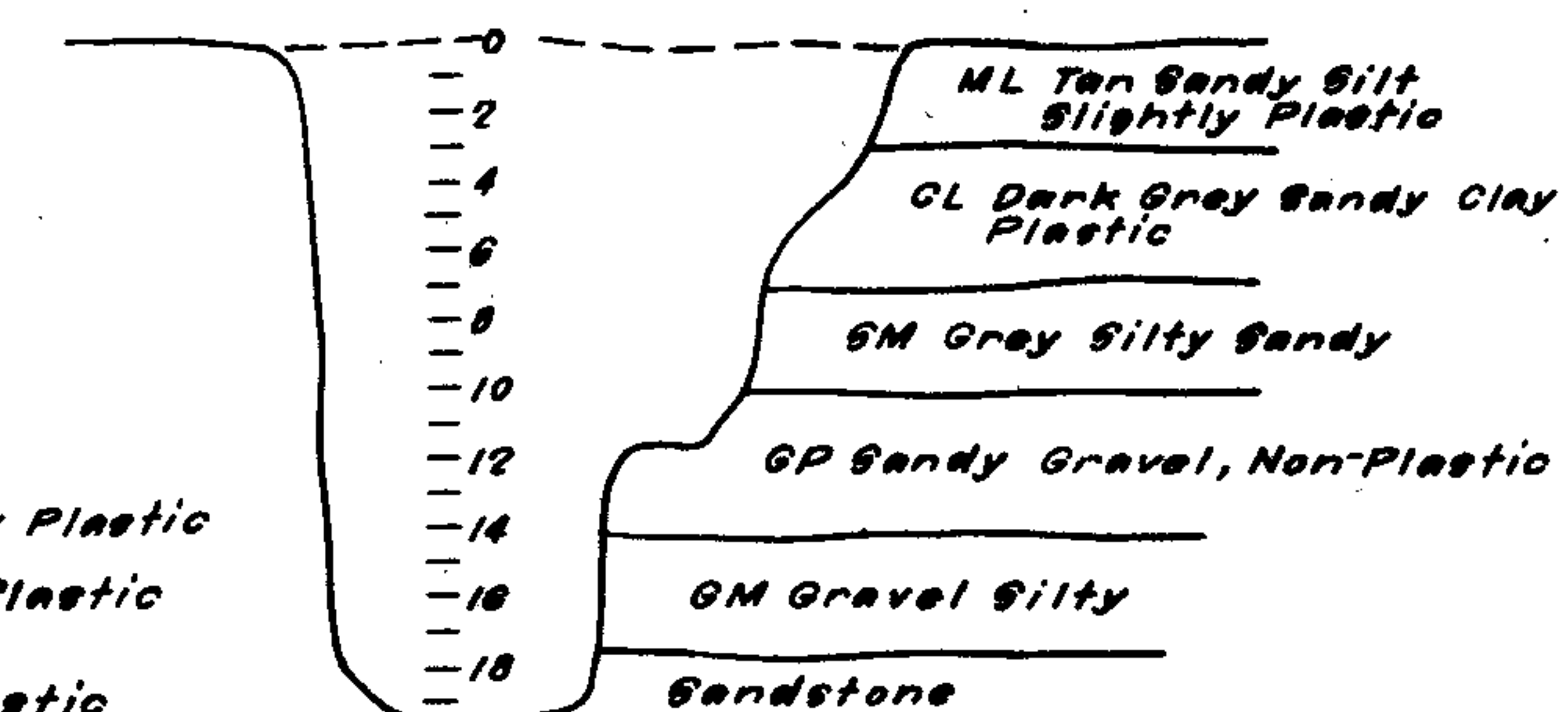
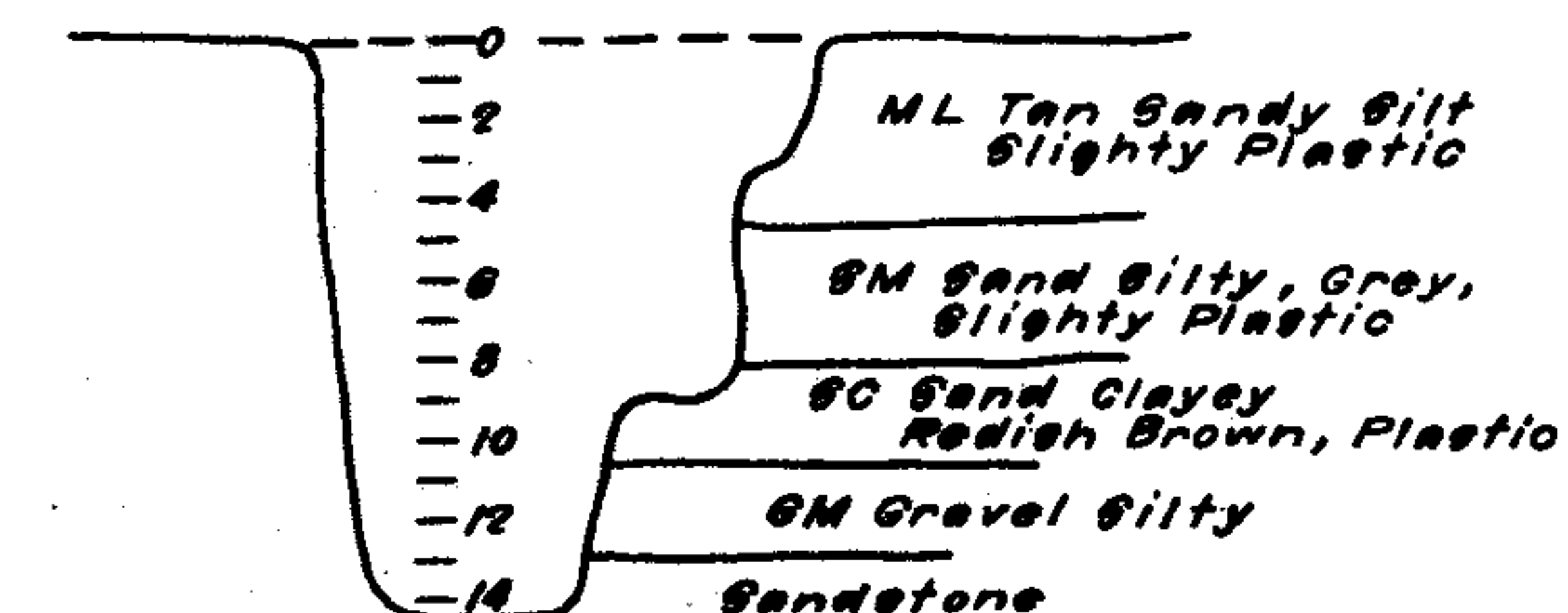
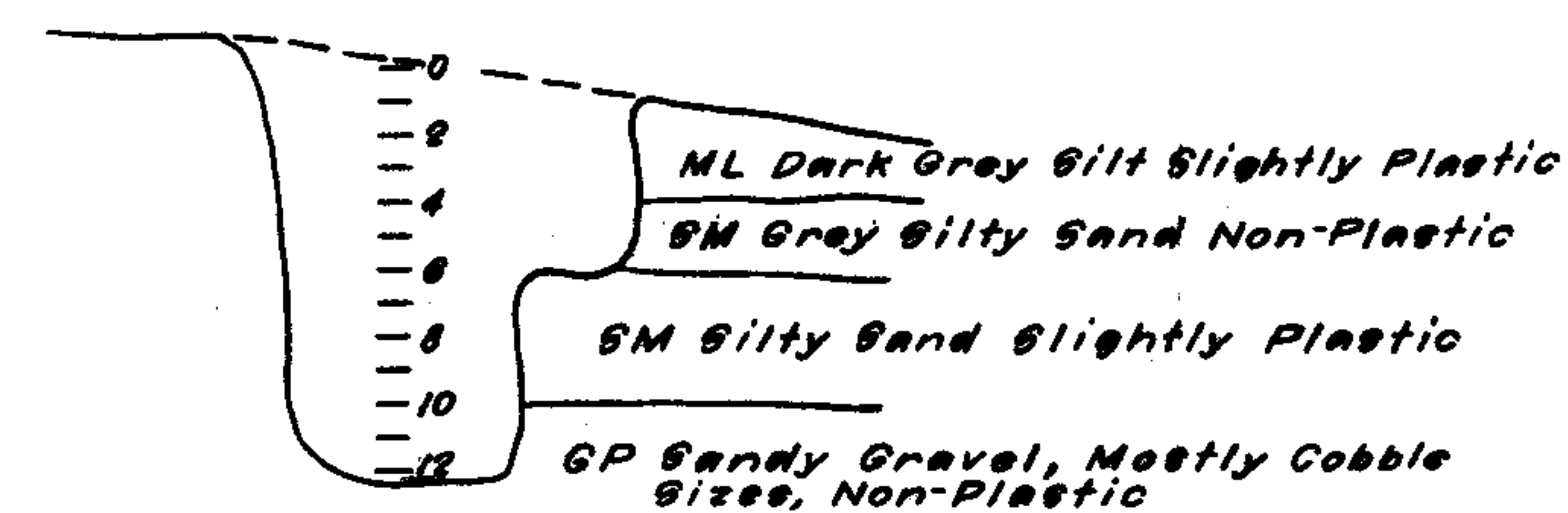
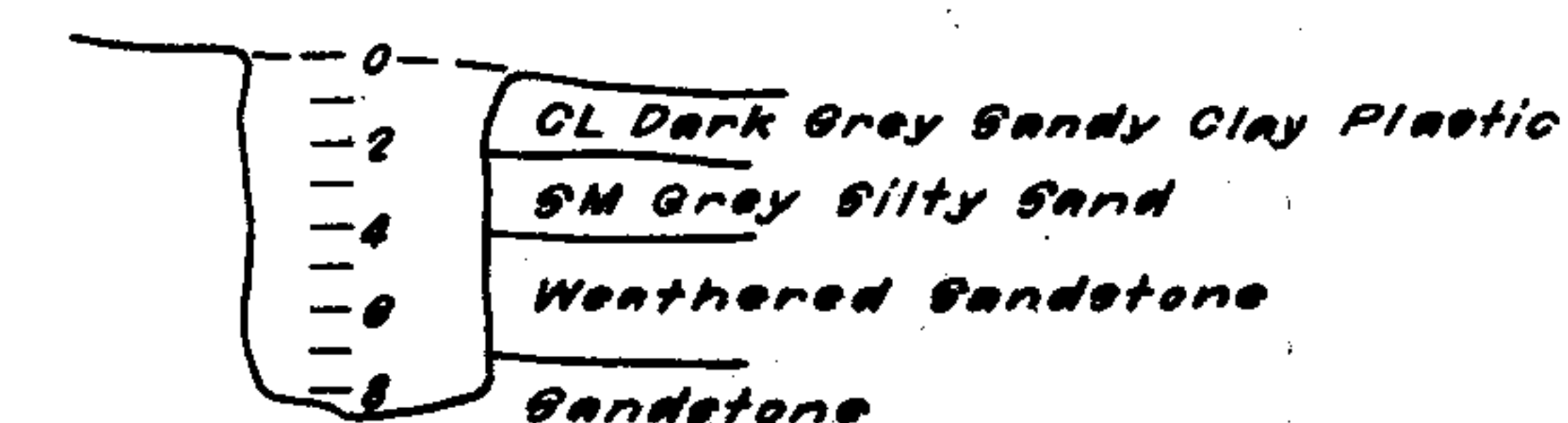
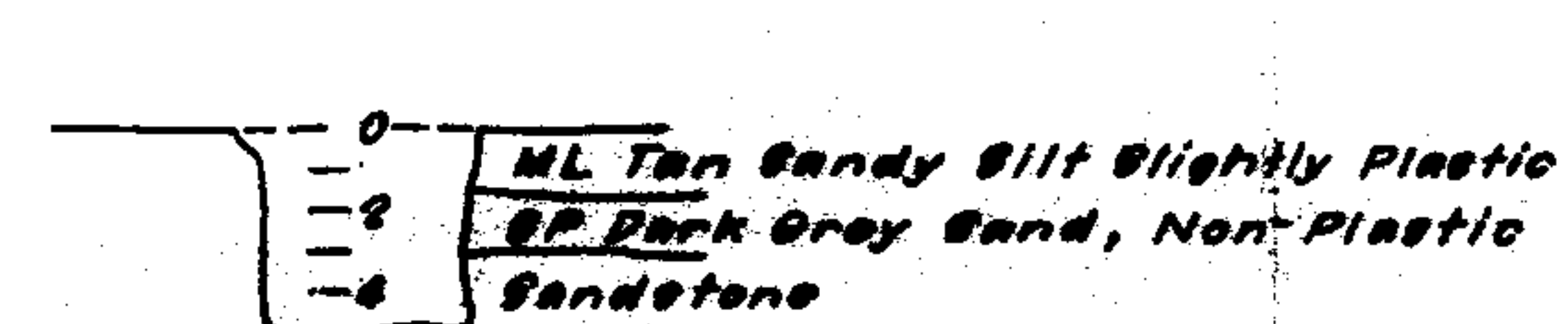
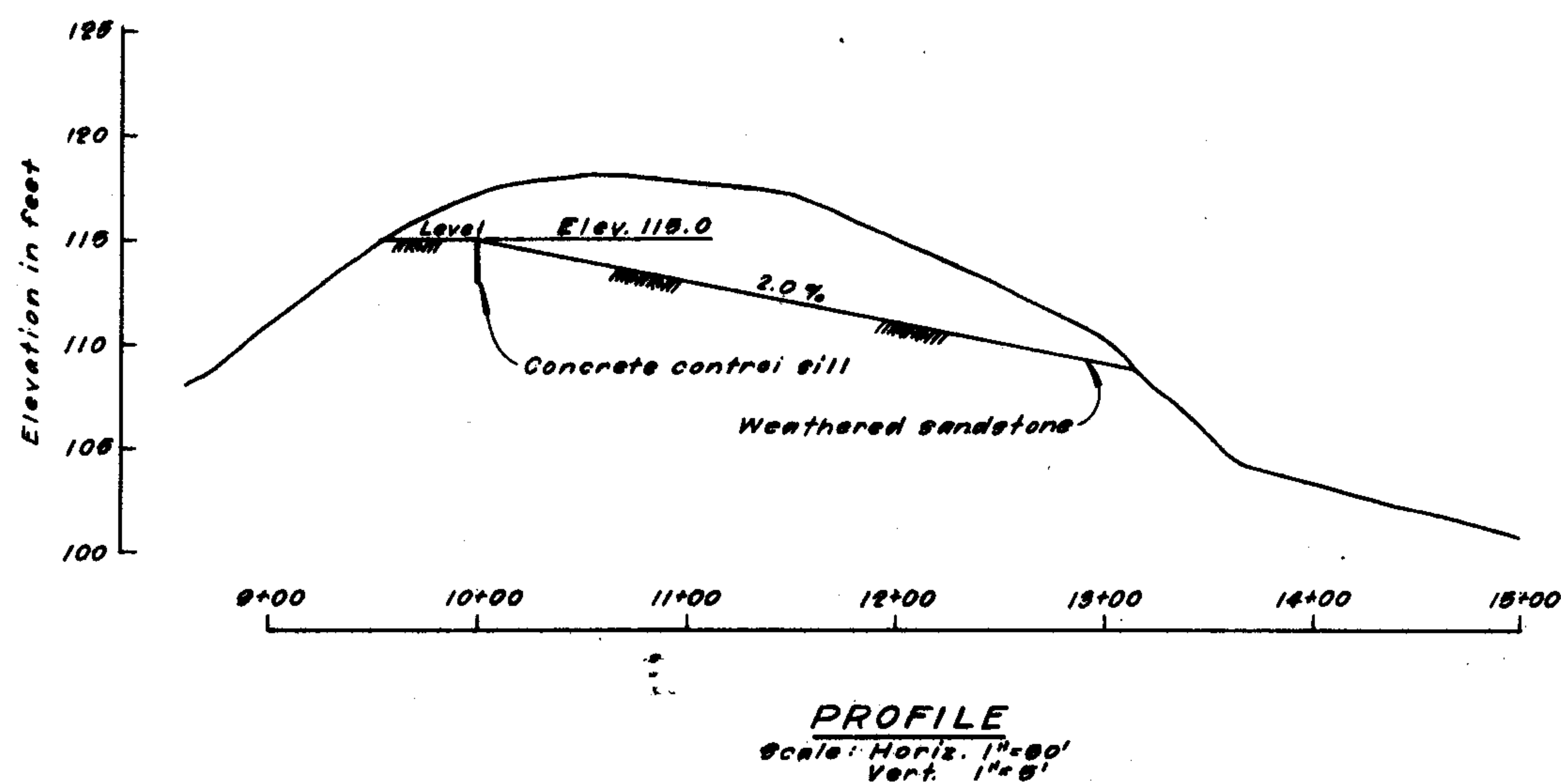
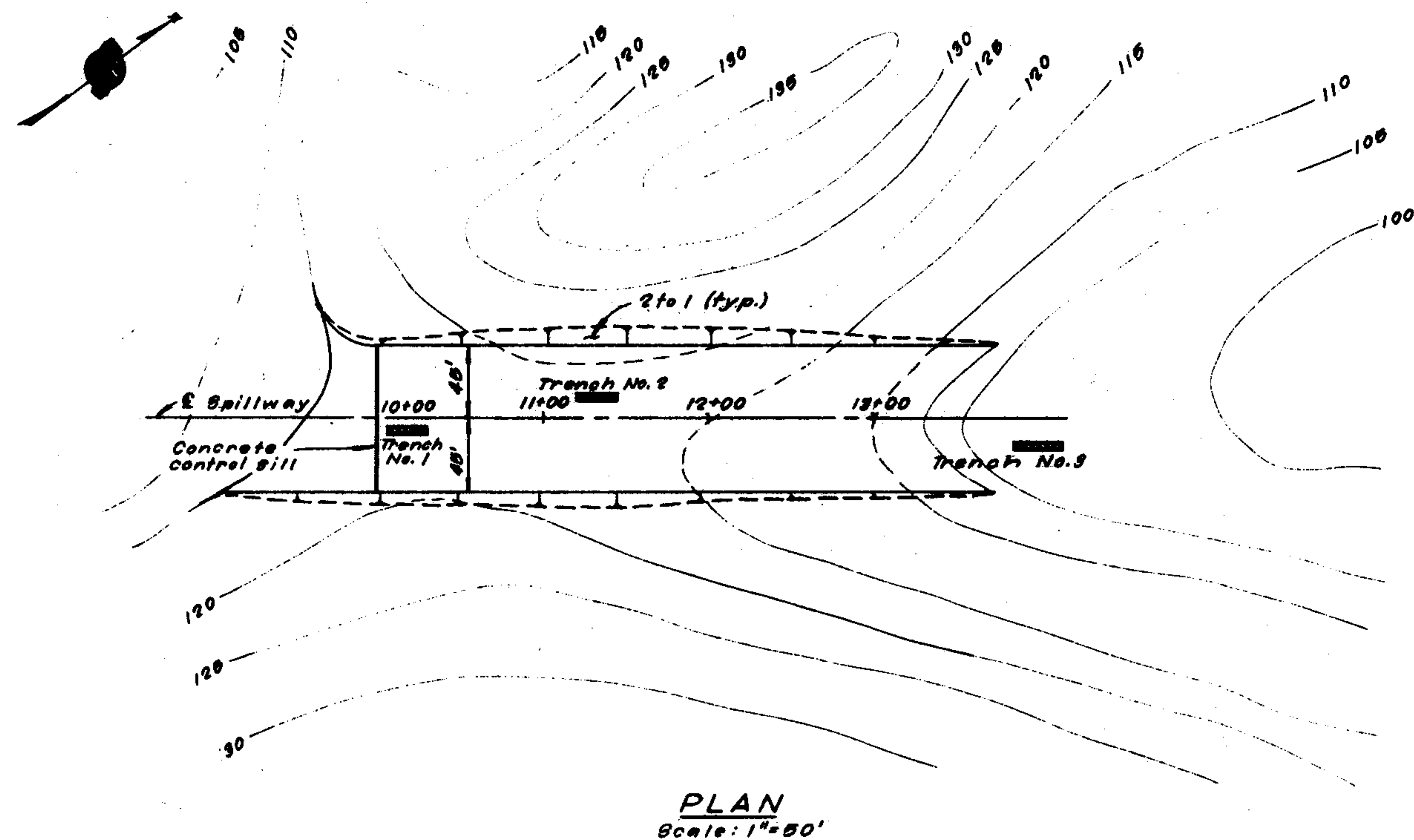
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

SWEETWATER DAM AND RESERVOIR

DAM

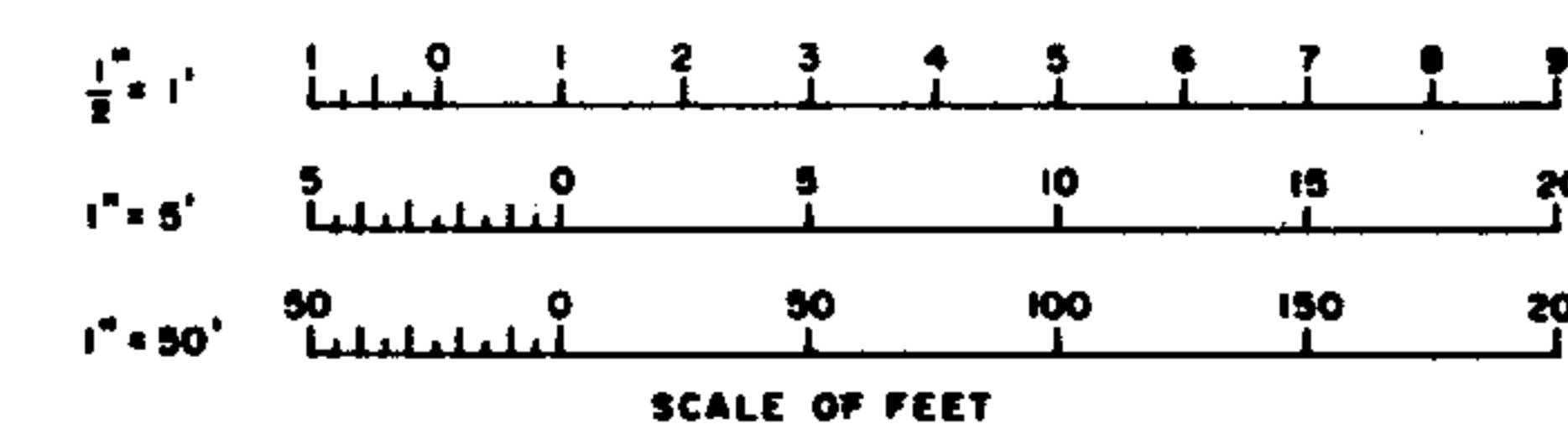
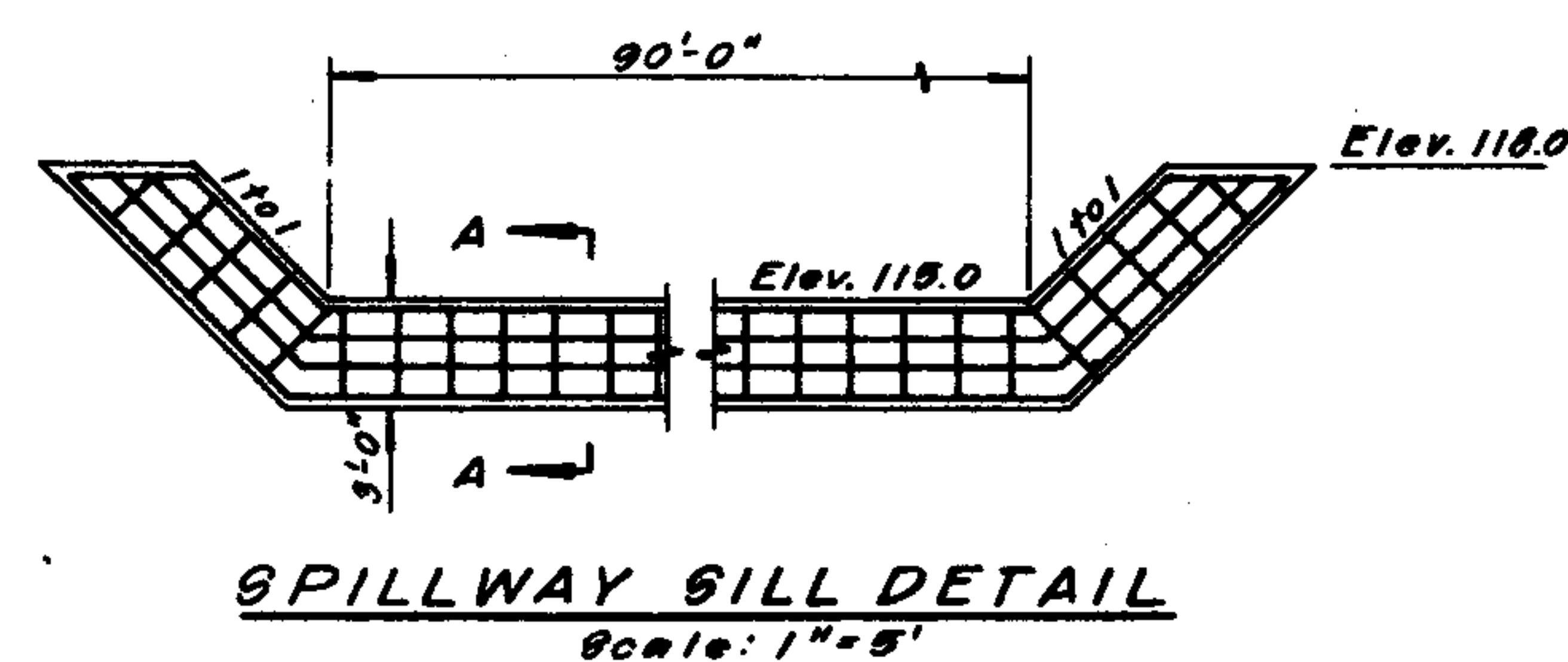
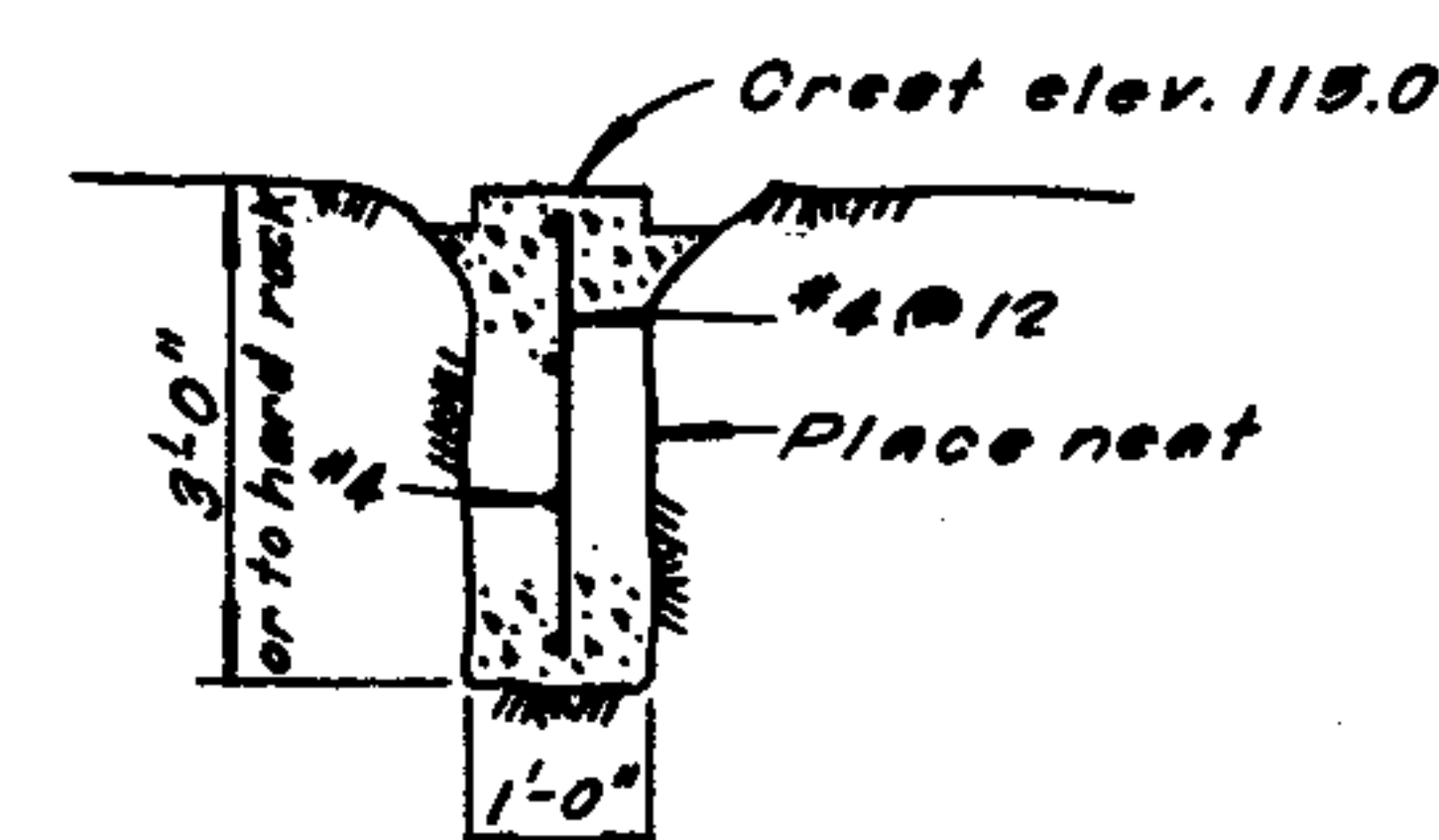
PLAN, PROFILE AND SECTIONS

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REVISIONS	DATE	DESCRIPTION	BY	APPROVED	APPROVAL RECOMMENDED:		DRAWING NO.		SHEET NO. 2



SPILLWAY TRENCHES

BORROW AREA TRENCHES
(See sheet No. 1 for location)



Think Safe - Be Safe

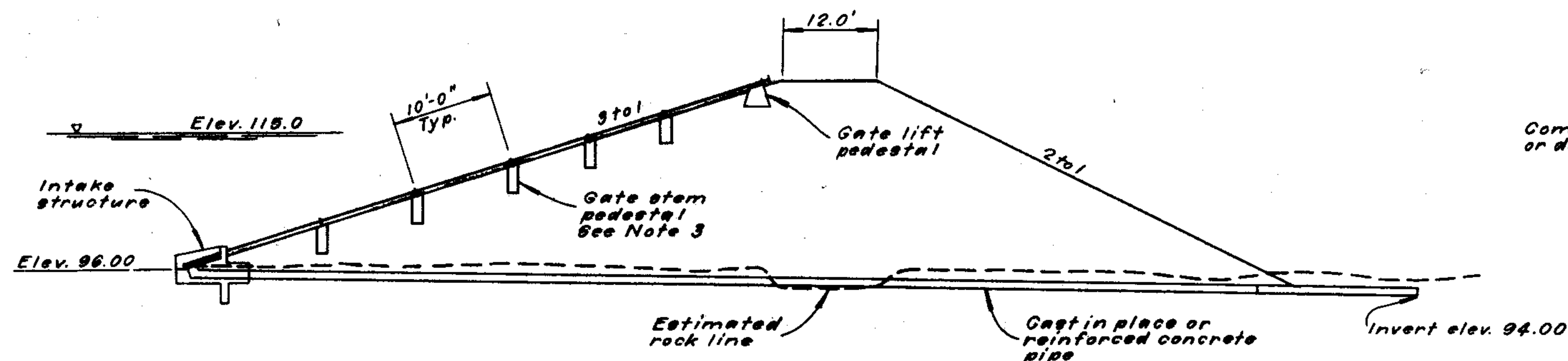
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

SWEETWATER DAM AND RESERVOIR

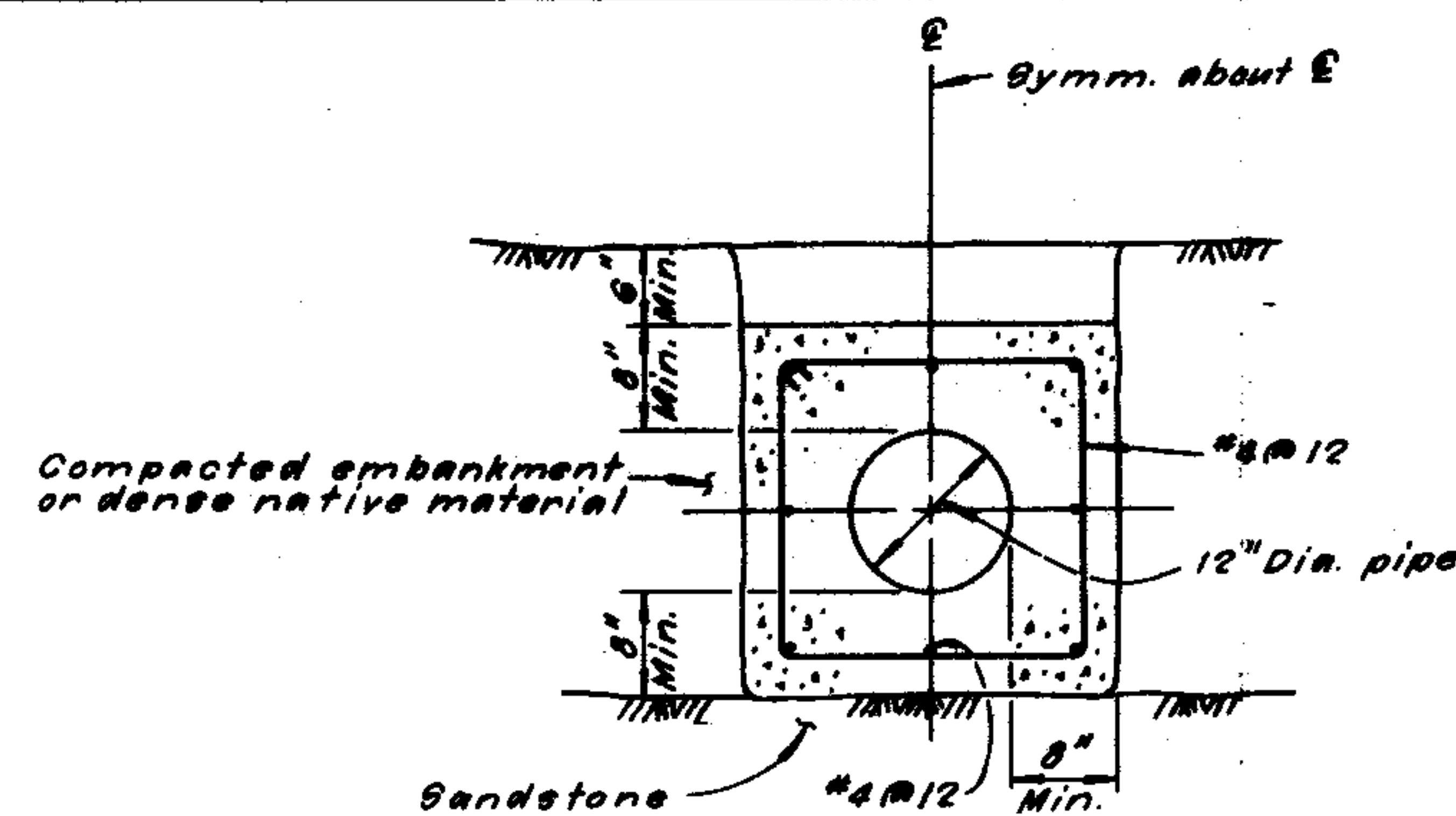
SPILLWAY

PLAN, PROFILE AND SECTIONS

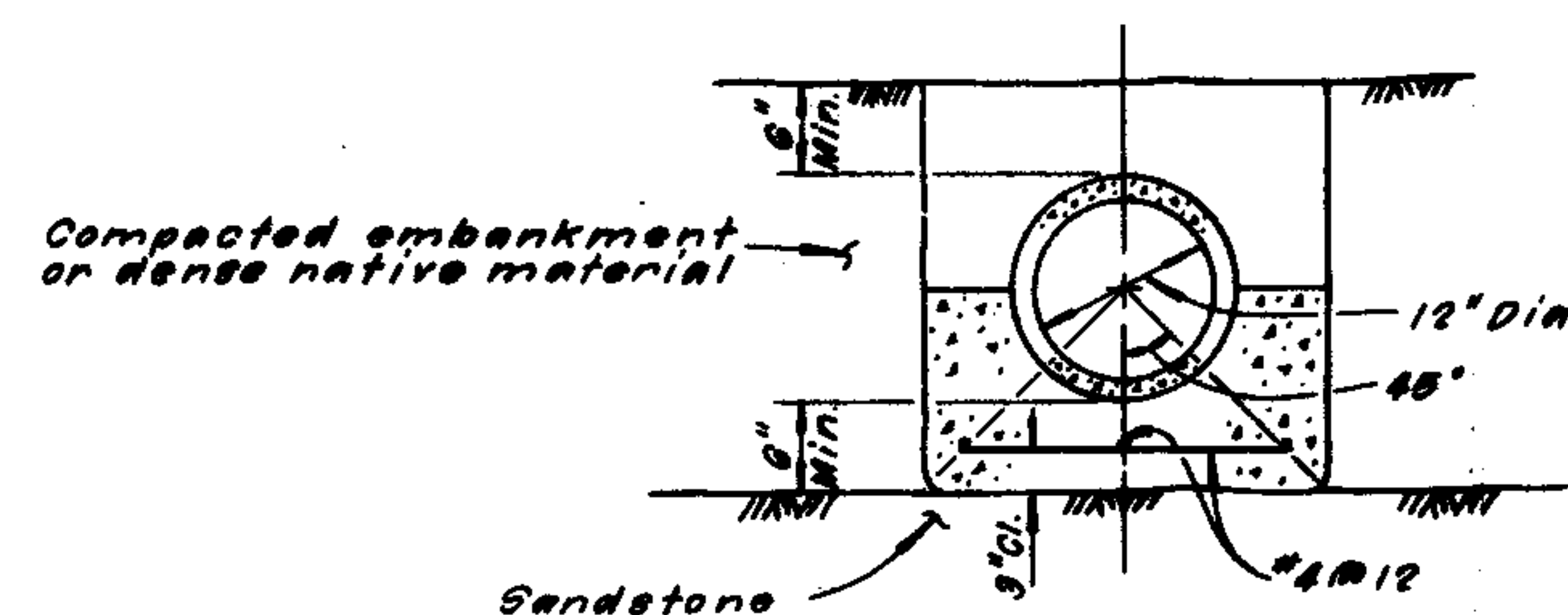
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					APPROVAL RECOMMENDED: _____					
					APPROVAL RECOMMENDED: _____					
REV.	DATE	BY	REASON FOR	REV.	DATE	DRAWING NO. _____		SHEET NO. _____		
REVISION			CHANGE	REVISION						



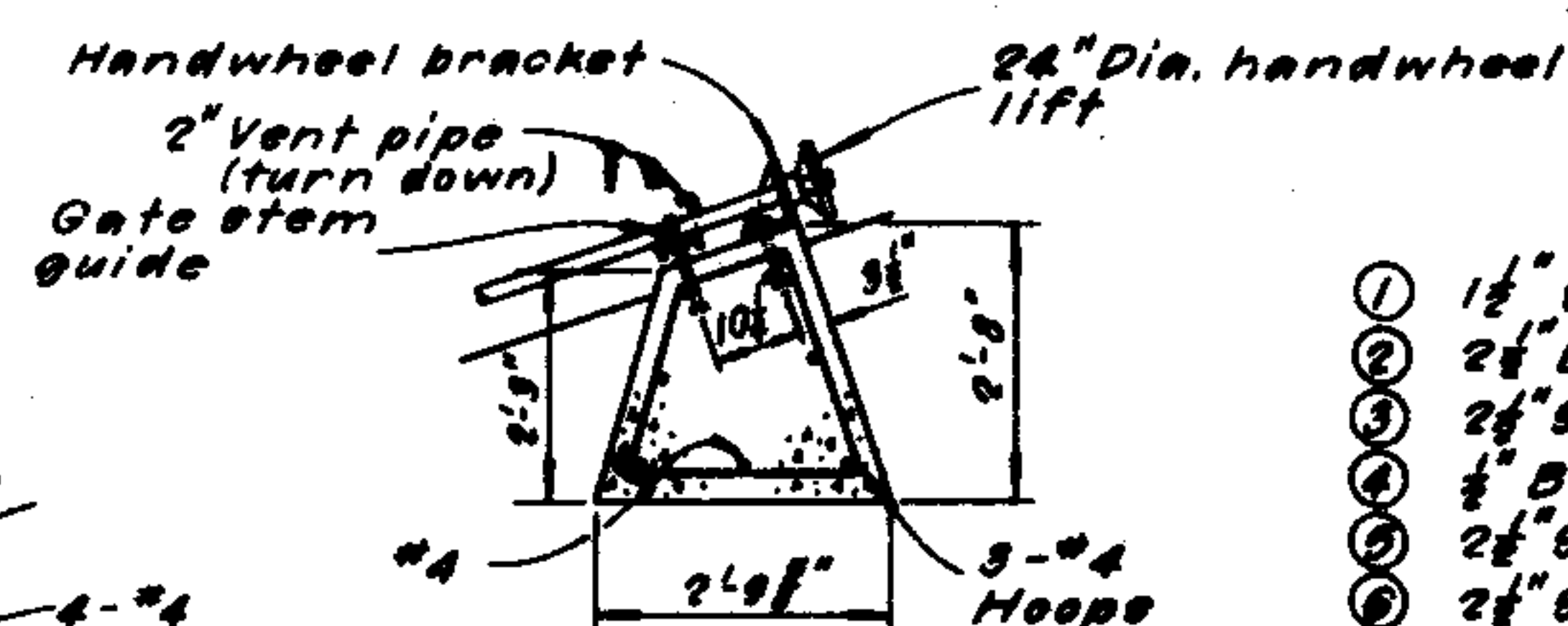
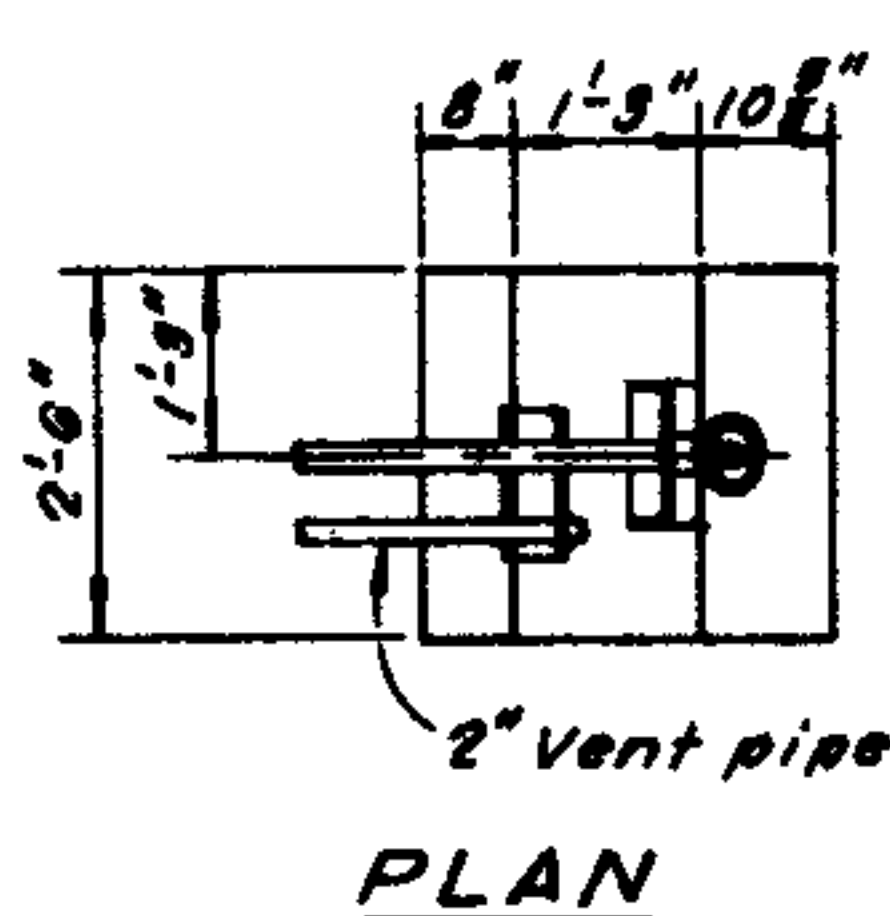
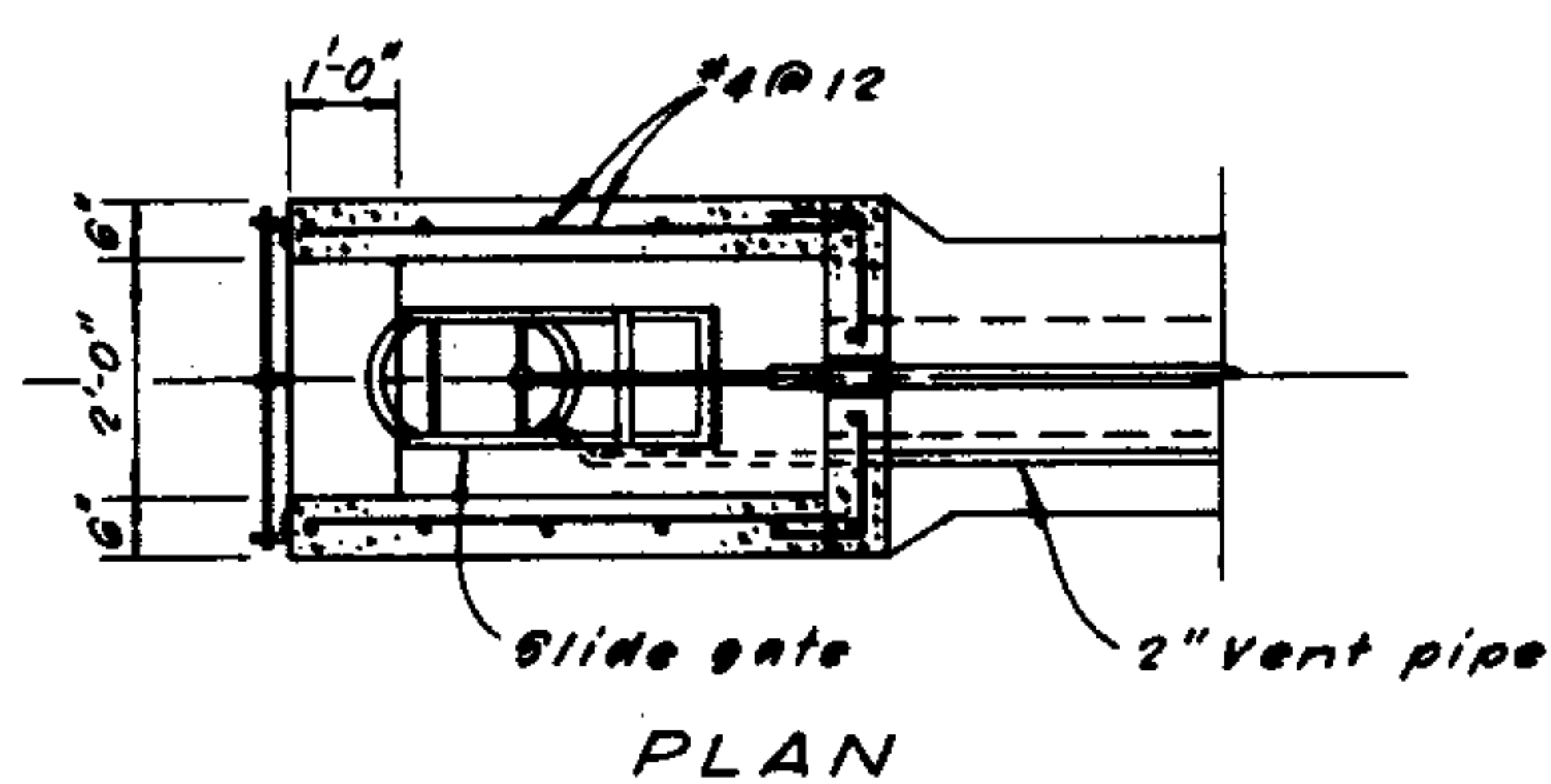
PROFILE - CENTERLINE OUTLET
Scale: 1"=10'



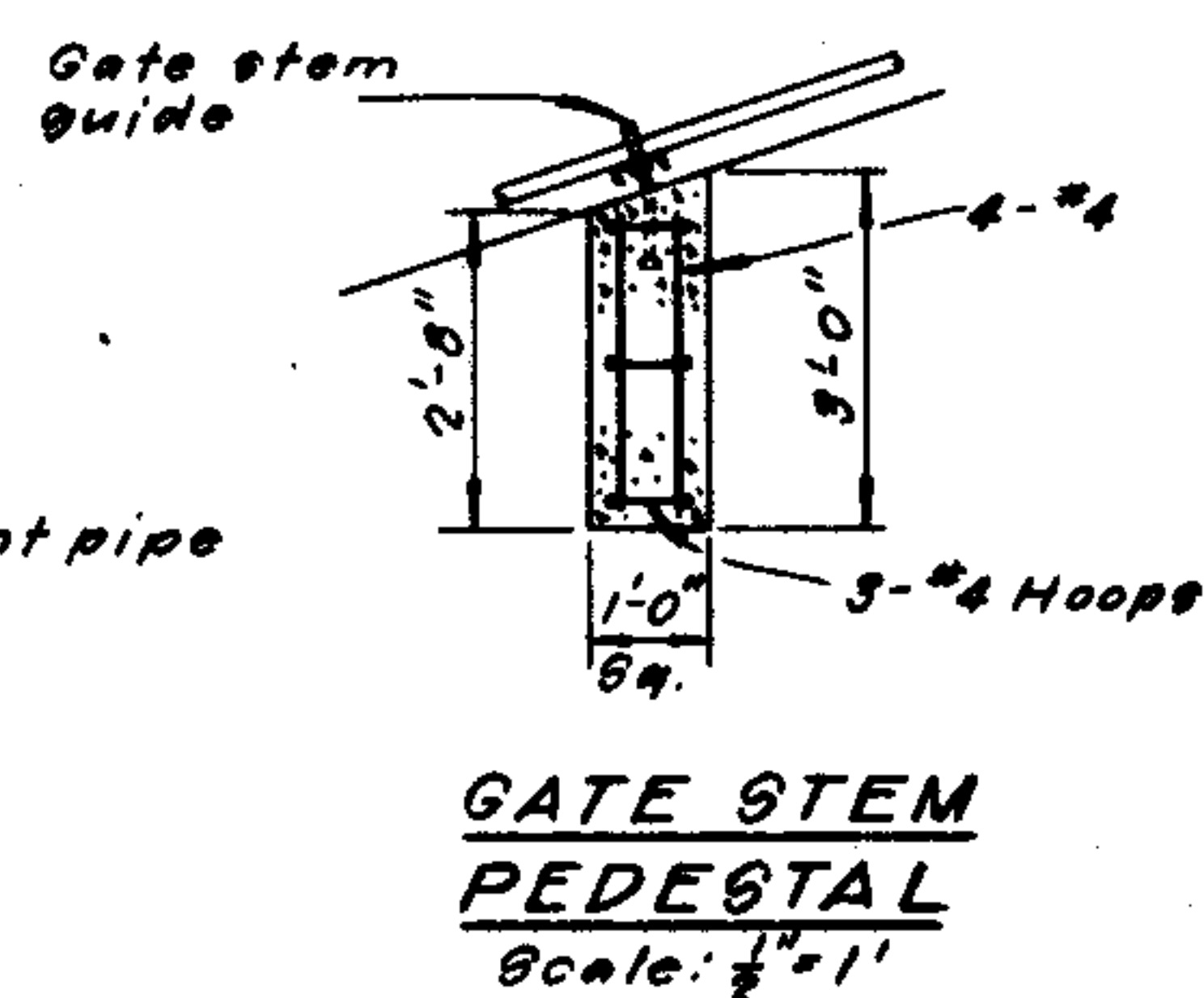
SECTION
CAST IN PLACE PIPE
Scale: 1"=1'



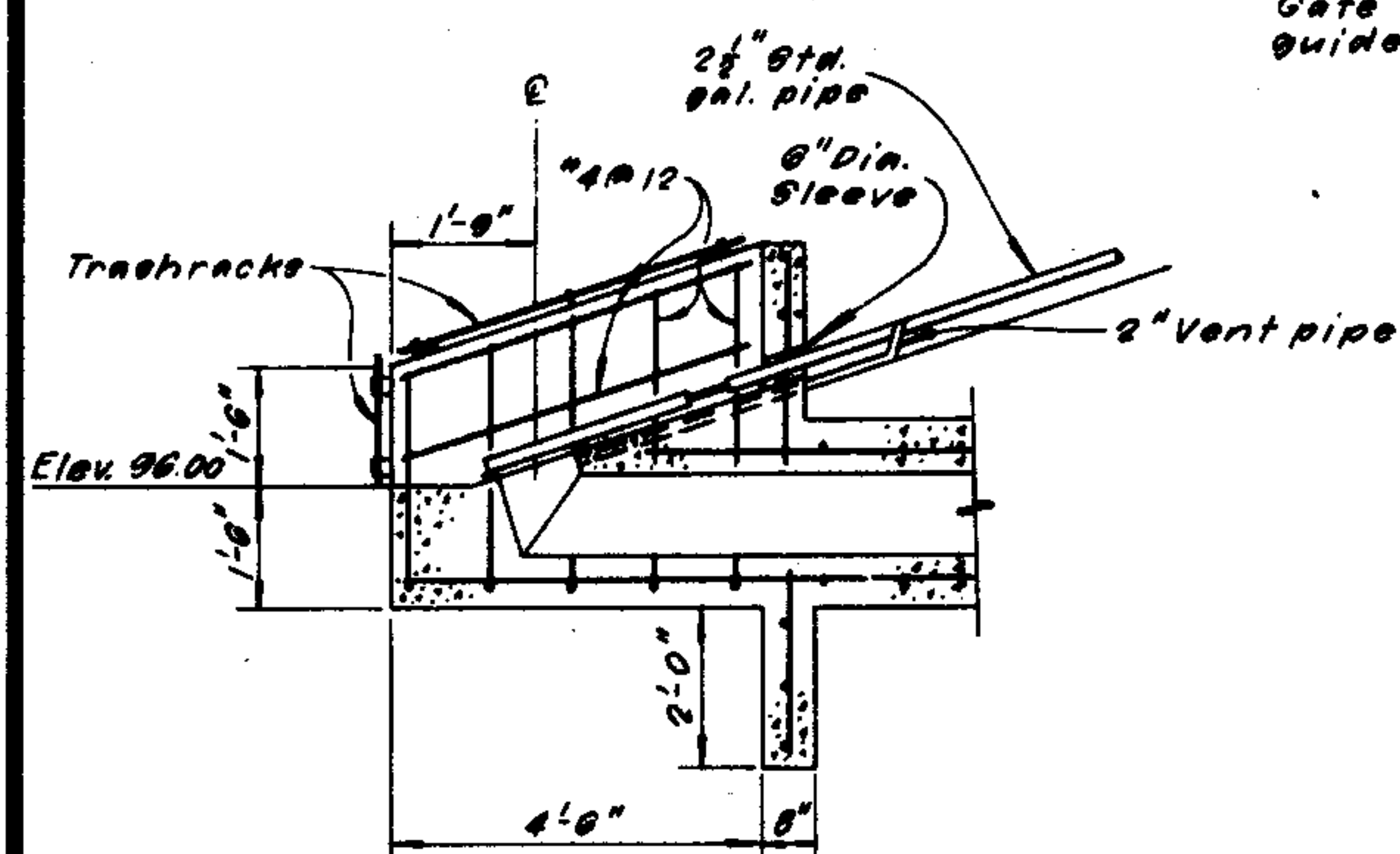
SECTION
REINFORCED CONCRETE PIPE
Scale: 1"=1'



ELEVATION
GATE LIFT
PEDESTAL
Scale: 1/2"=1'

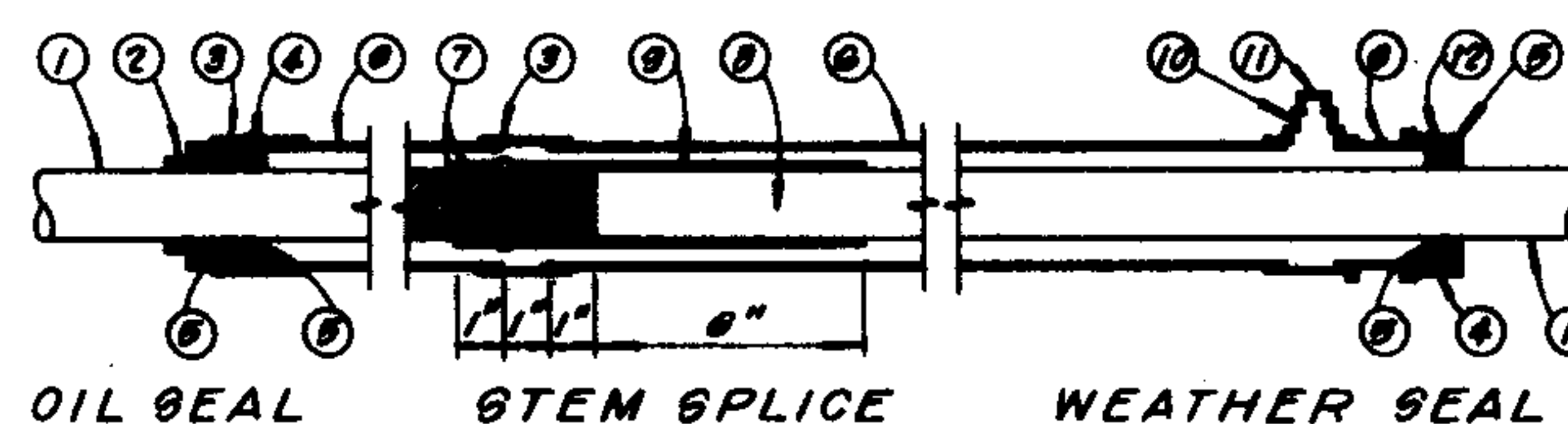


ELEVATION
GATE STEM
PEDESTAL
Scale: 1/2"=1'

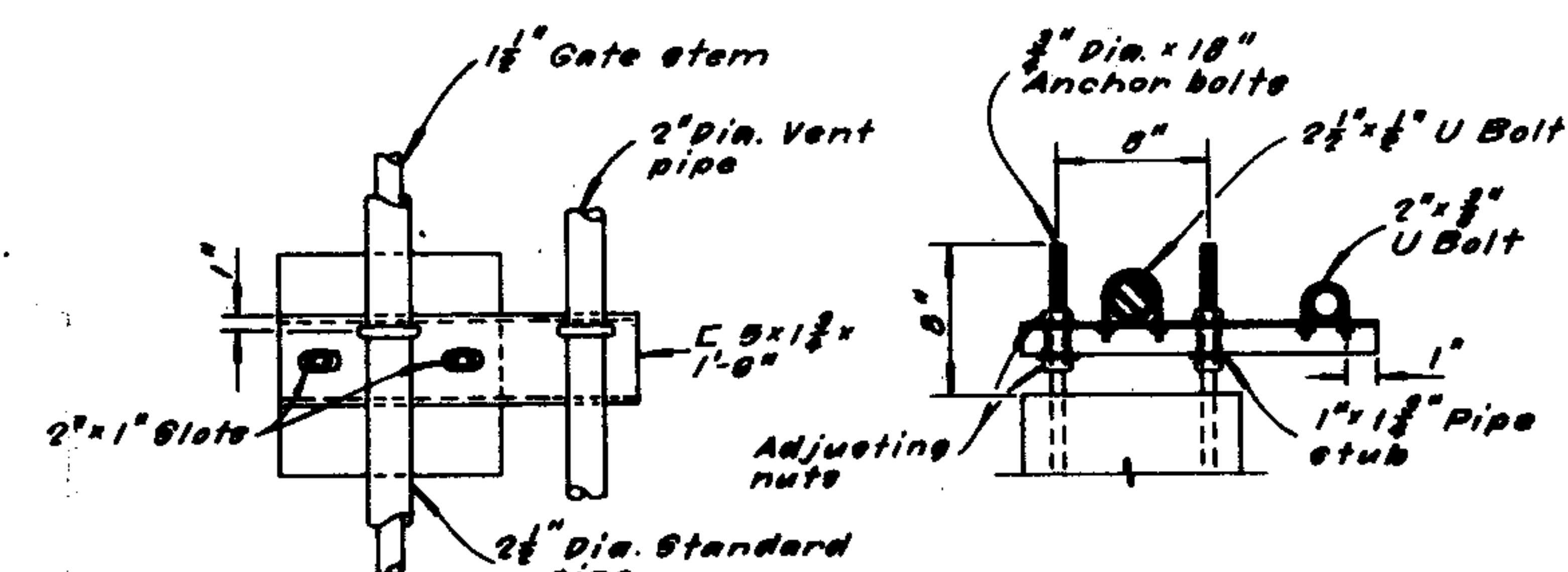


ELEVATION
INTAKE STRUCTURE
Scale: 1/2"=1'

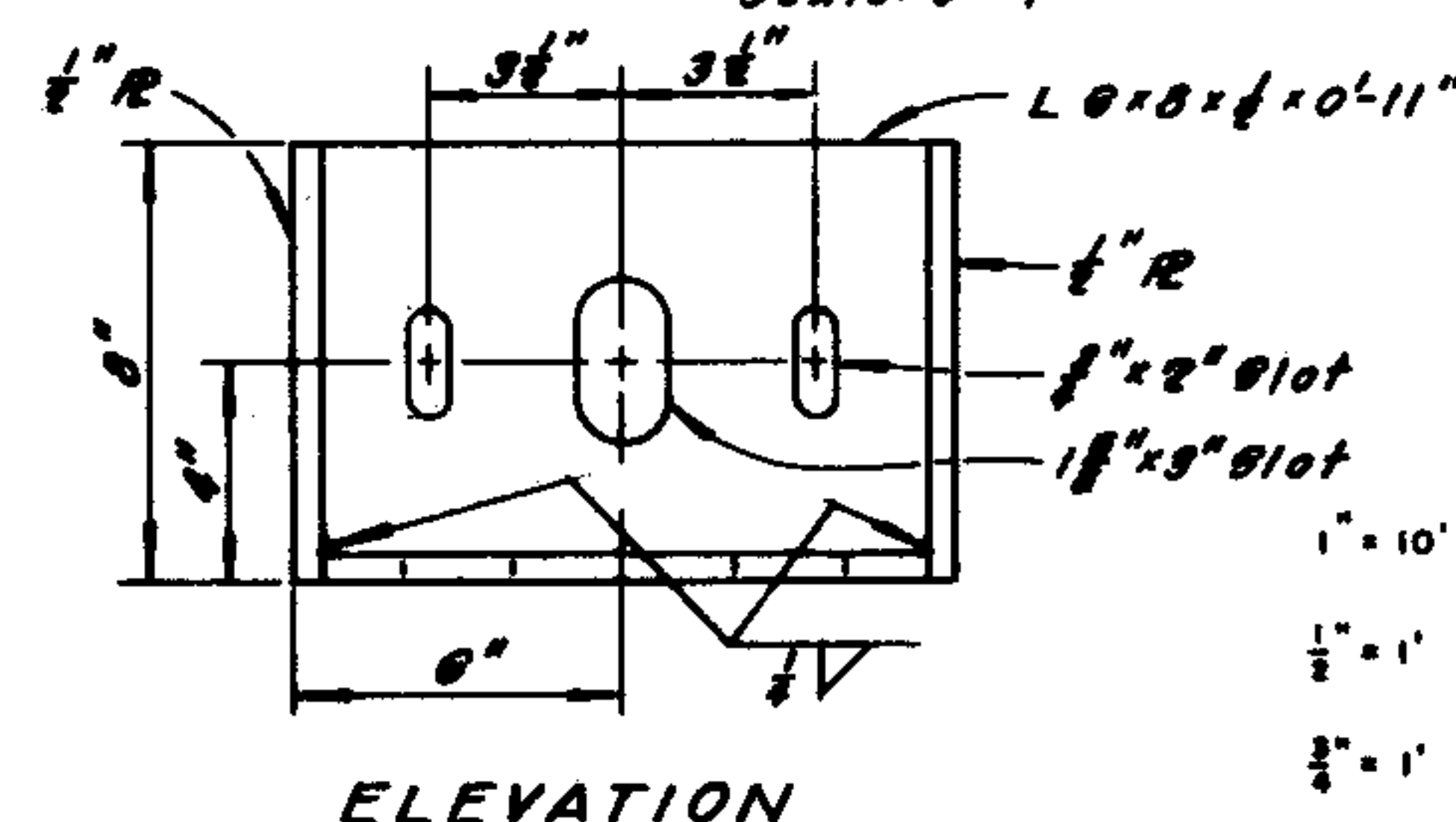
- 1 1/2" Stainless steel stem.
- 2 1/2" Bronze bushing, drill to stem dia. with sliding fit.
- 2 1/2" Standard galvanized coupling.
- 1/2" Braided waterproof flax or felt packing.
- 2 1/2" Steel washer, drill to fit stem dia. with sliding fit.
- 2 1/2" Standard galvanized pipe (splice as required)
- 2 - 3/8" x 3" Rivets peened to clear casing.
- 1 1/2" Carbon steel stem (All sections completely encased).
- 1 1/2" I.D. x 9" Long seamless steel tubing (2 1/2" O.D.).
- 2 1/2" x 1" Reducing tee.
- 1" Filler plug.
- 2 1/2" Standard galvanized cap.



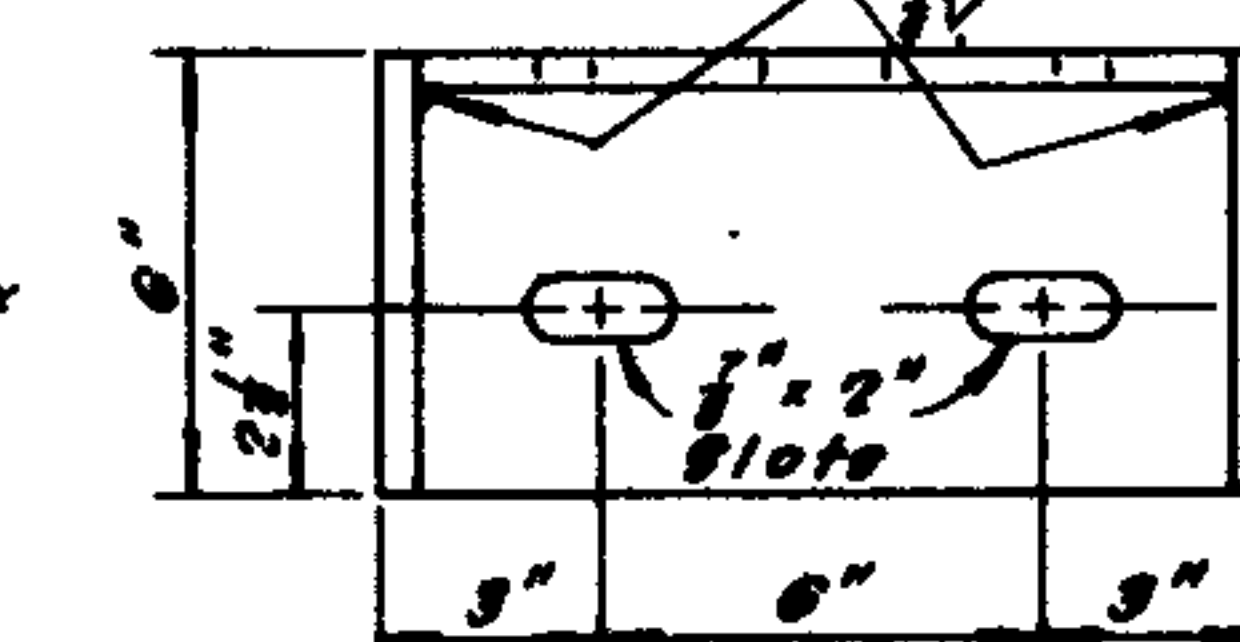
ELEVATION
GATE STEM
Scale: 3/4"=1'



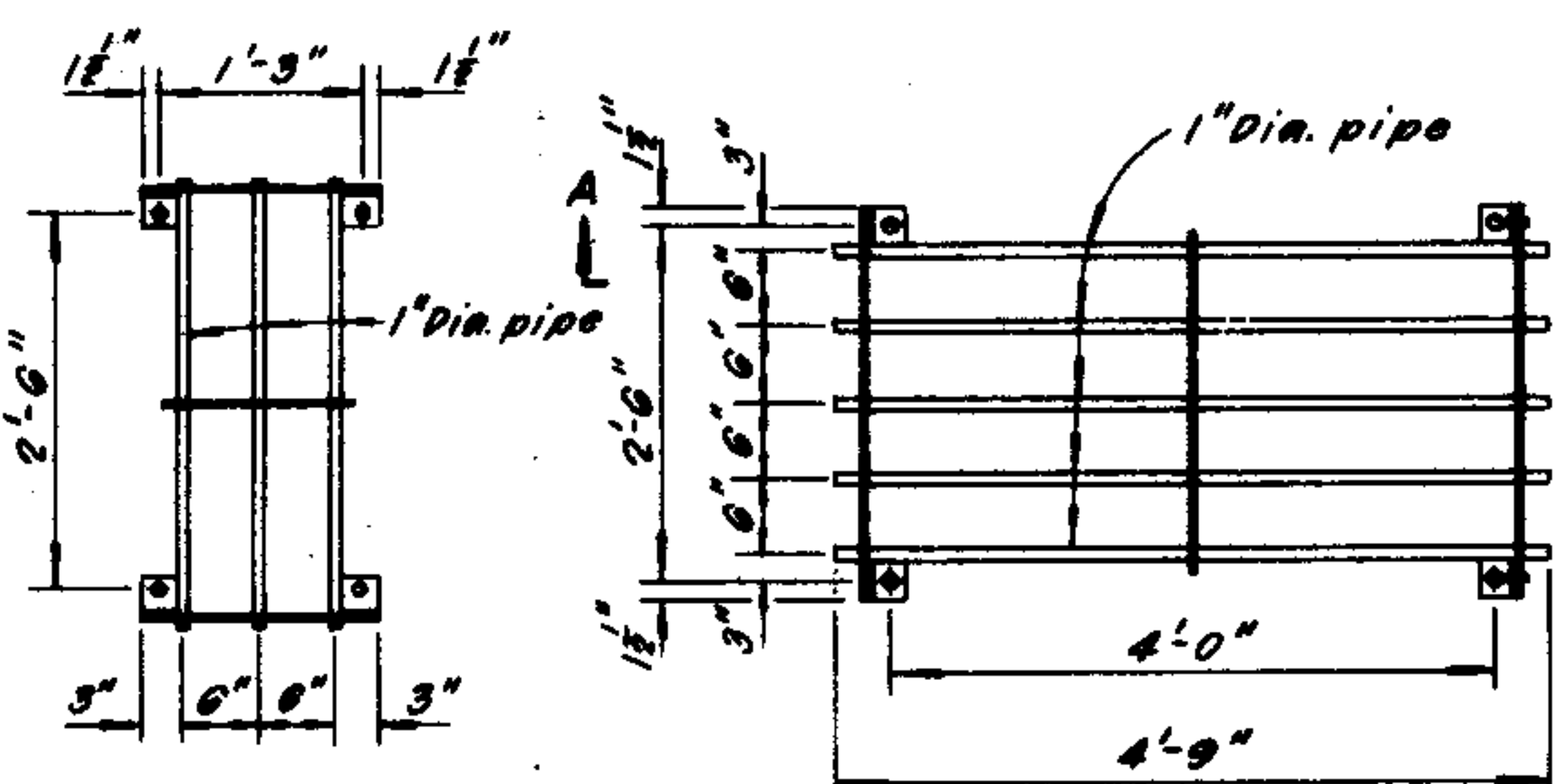
ELEVATION
GATE STEM GUIDE
Scale: 1 1/2"=1'



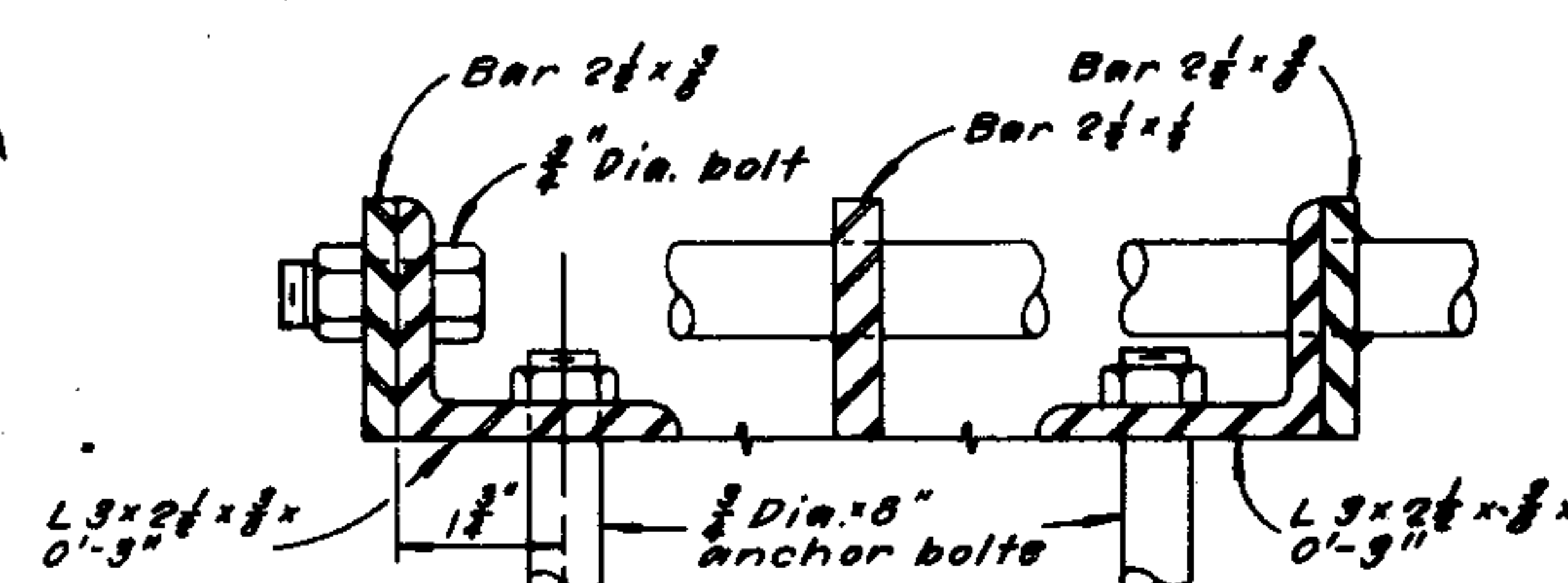
ELEVATION
HANDWHEEL BRACKET



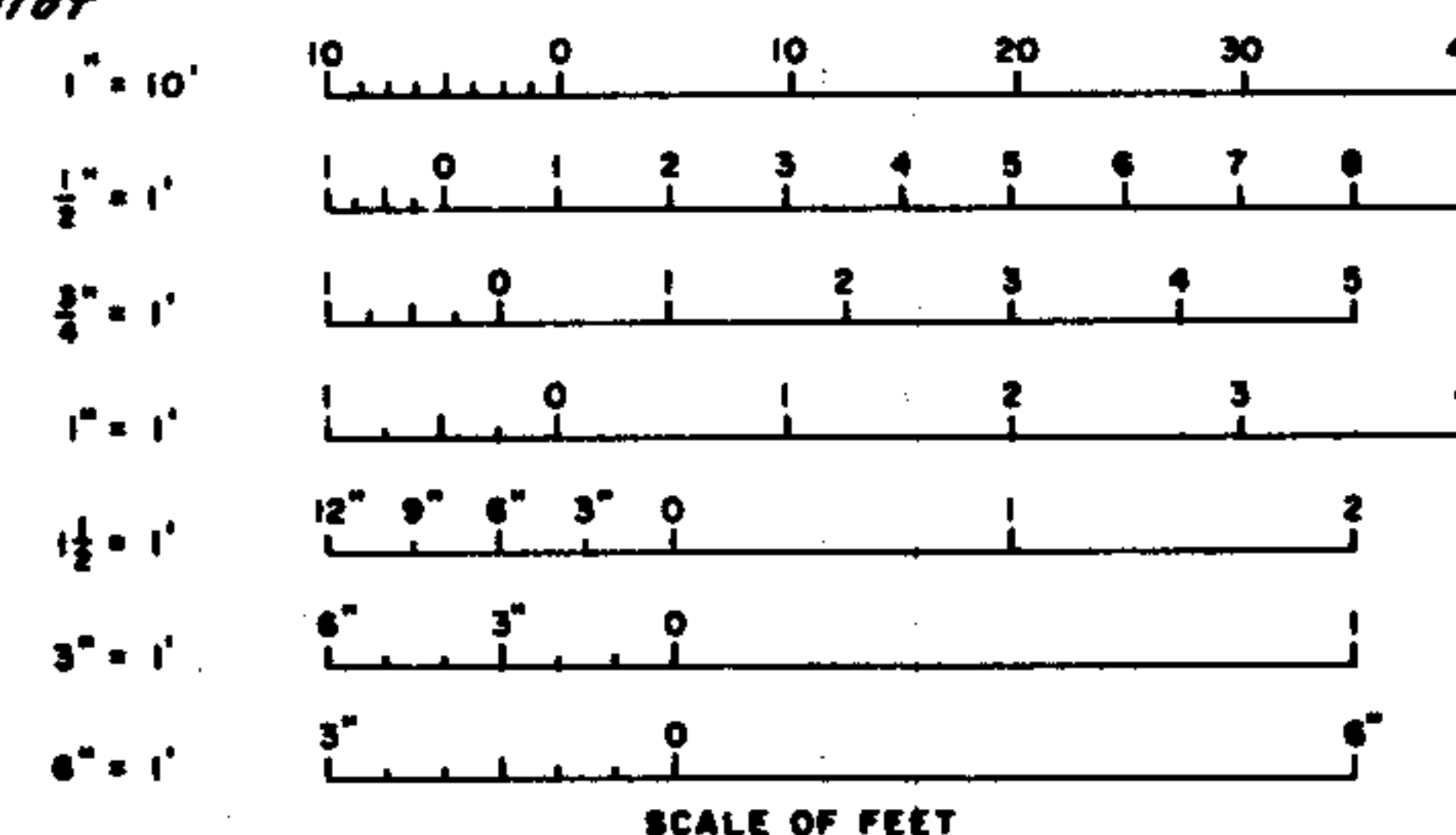
PLAN
HANDWHEEL BRACKET
Scale: 3/4"=1'



ELEVATION
TRASH RACK
Scale: 3/4"=1'



SECTION A-A
Scale: 6"=1'



- NOTE:
1. Outlet conduit alignment shall be located in the field after stripping operations and after the embankment cutoff trench is excavated.
 2. All exposed metalwork, including anchor bolts, to be galvanized unless otherwise noted.
 3. Gate stem pedestals may be omitted at the Contractor's option if the entire gate stem is installed in the compacted embankment.
 4. Fill gate stem sleeve with #20 SAE oil.

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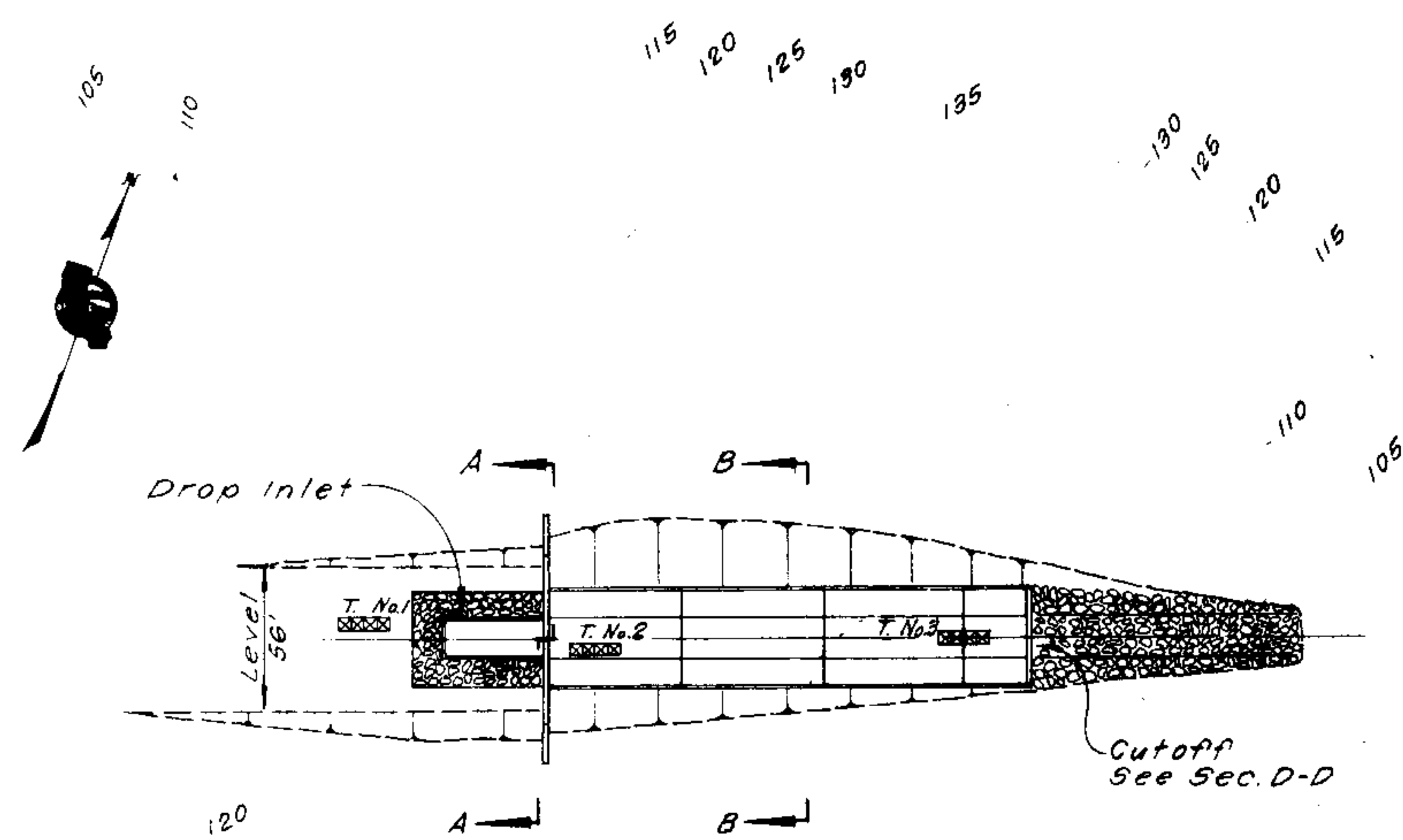
STATE OF CALIFORNIA
THE RESOURCE AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

SWEETWATER DAM AND RESERVOIR

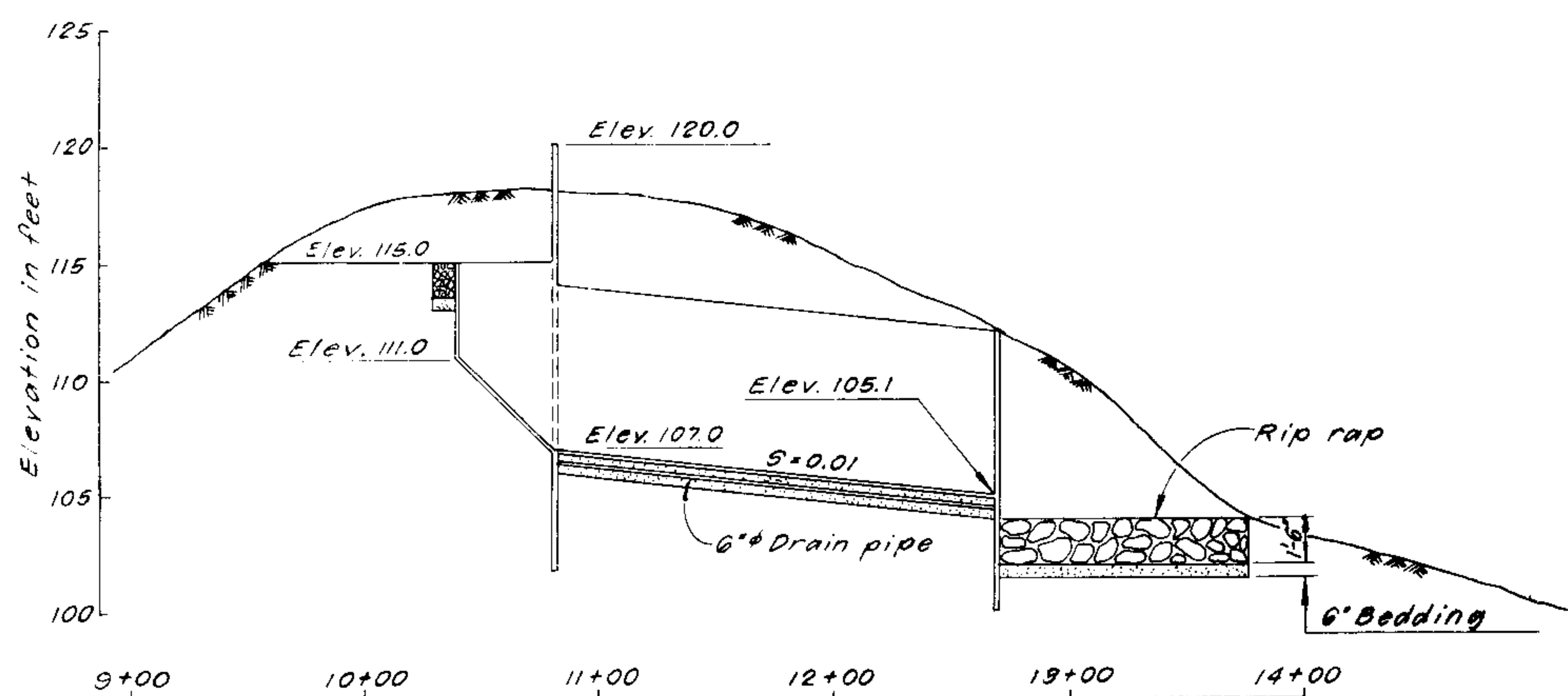
OUTLET

PROFILE AND SECTIONS

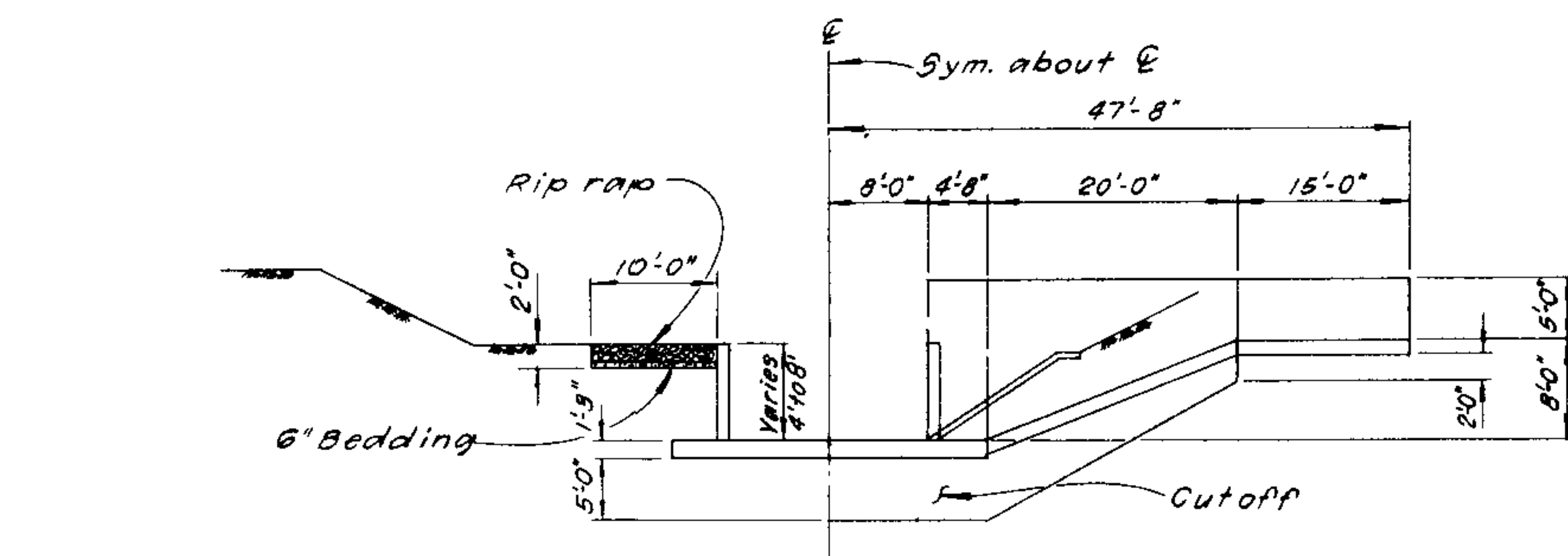
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APPROVAL RECOMMENDED:		APPROVAL RECOMMENDED:		DRAWING NO.	
APPROVAL RECOMMENDED:		APPROVAL RECOMMENDED:		SHEET NO.	
				4	



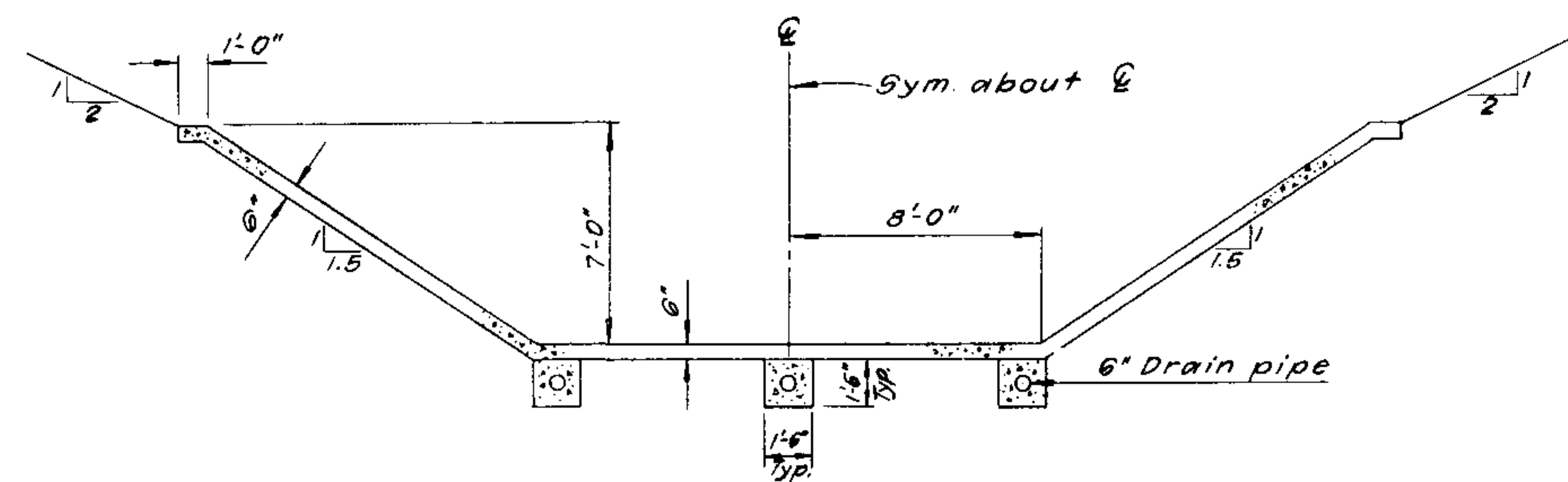
PLAN
Scale: 1"=50'



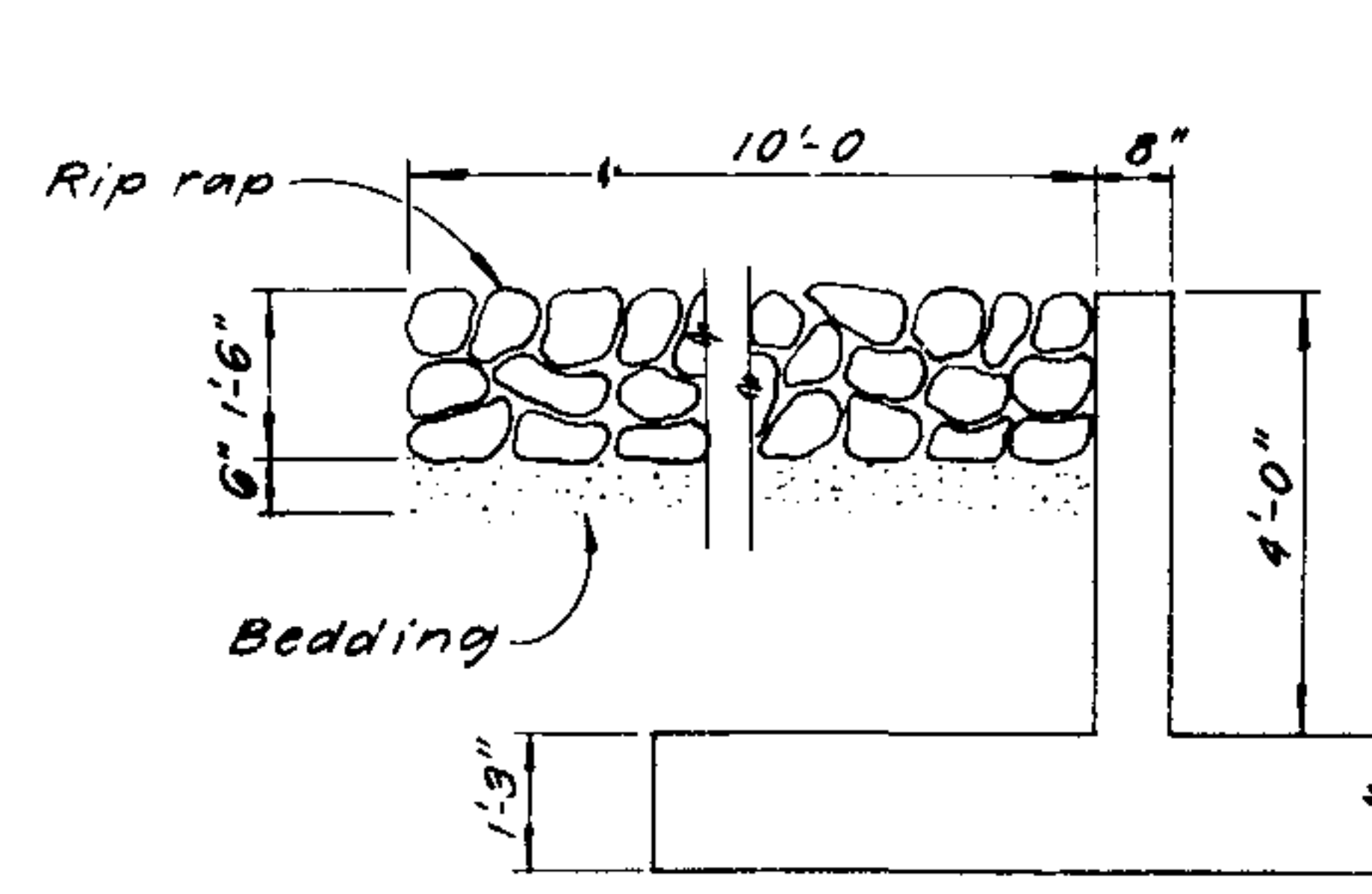
PROFILE
Scale: Horiz. 1"=50'
Vert. 1"=5'



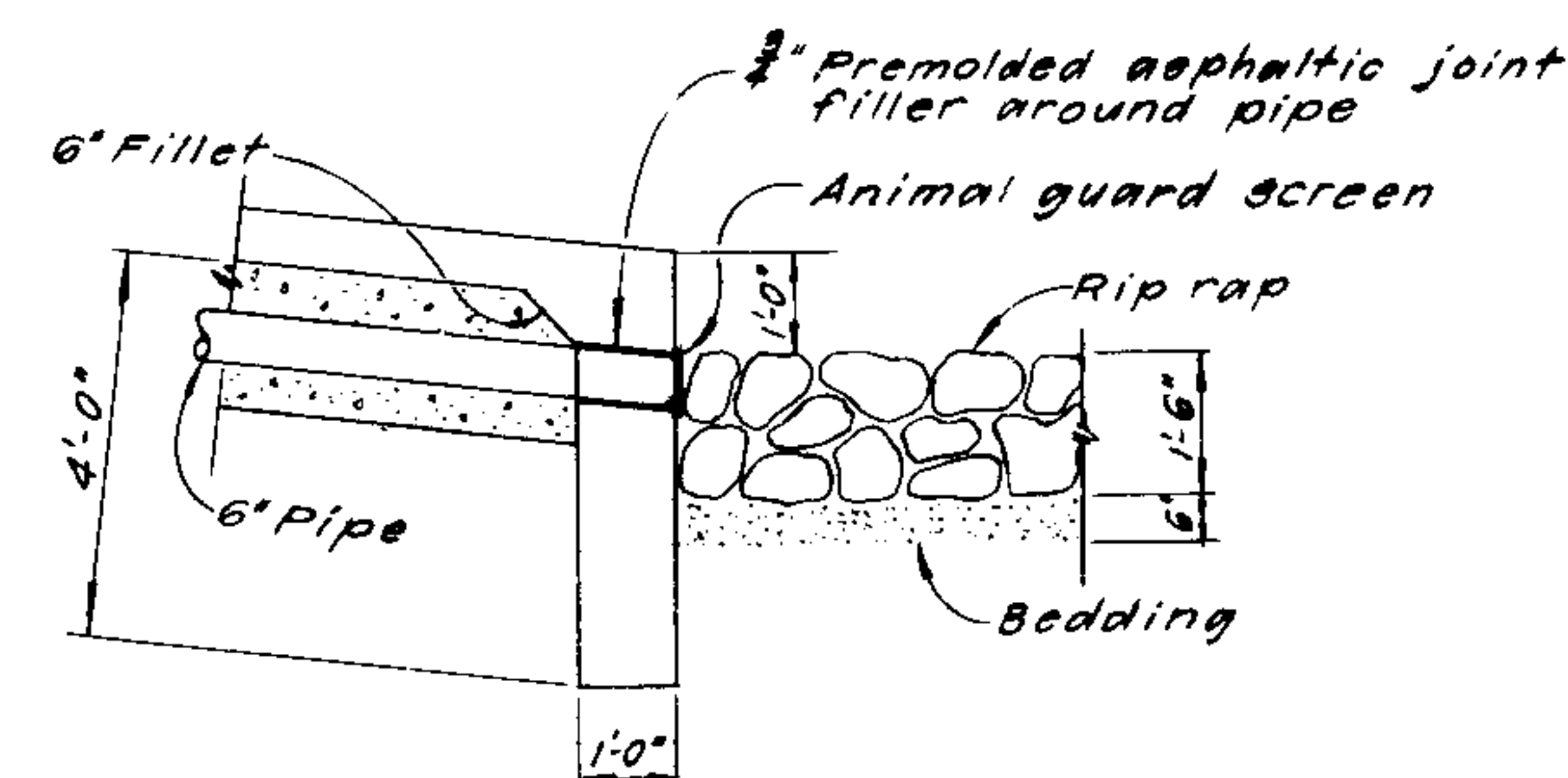
SECTION A-A
Scale: 3/8"=1'



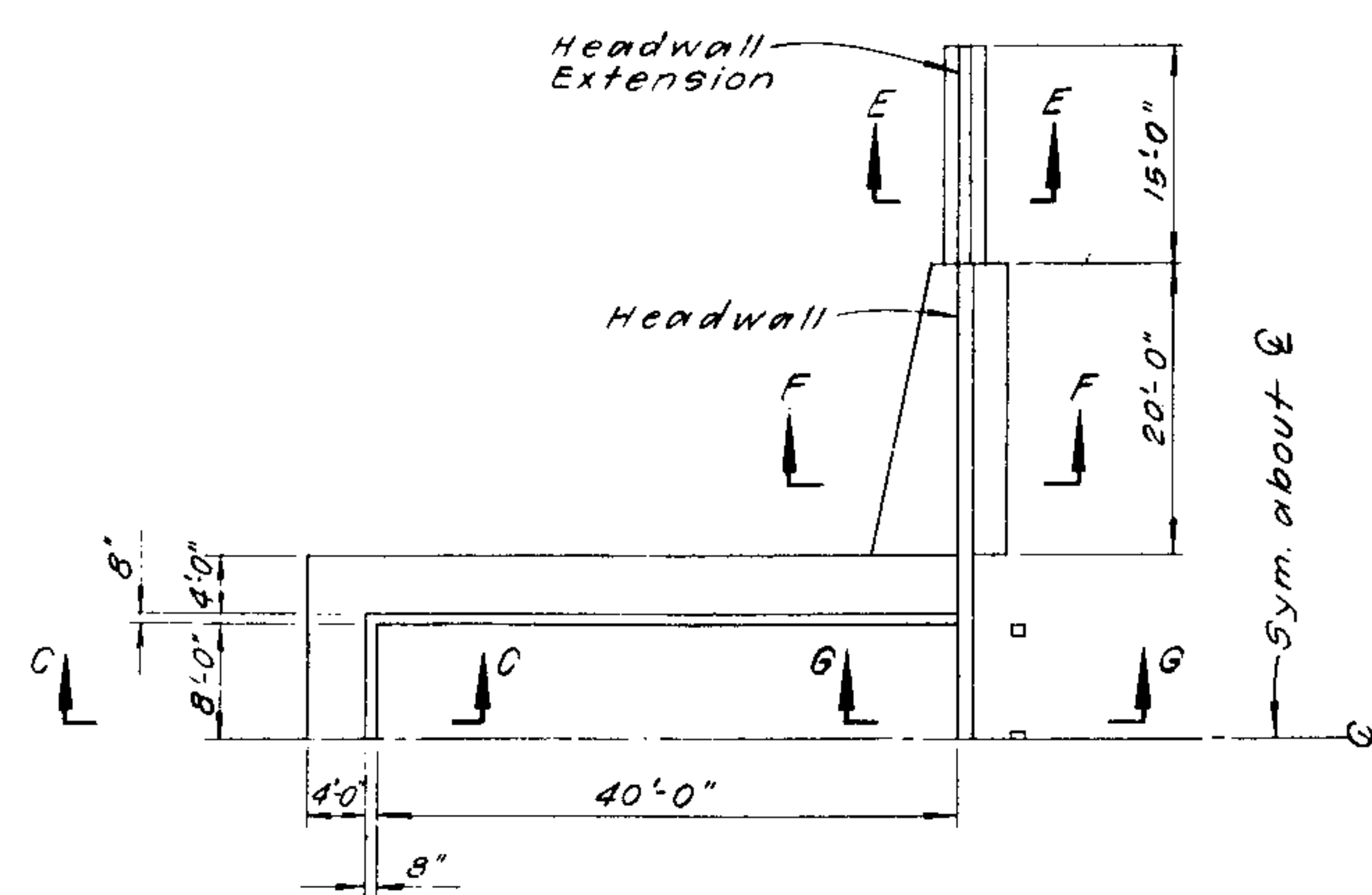
SECTION B-B
Scale: 1/4"=1'



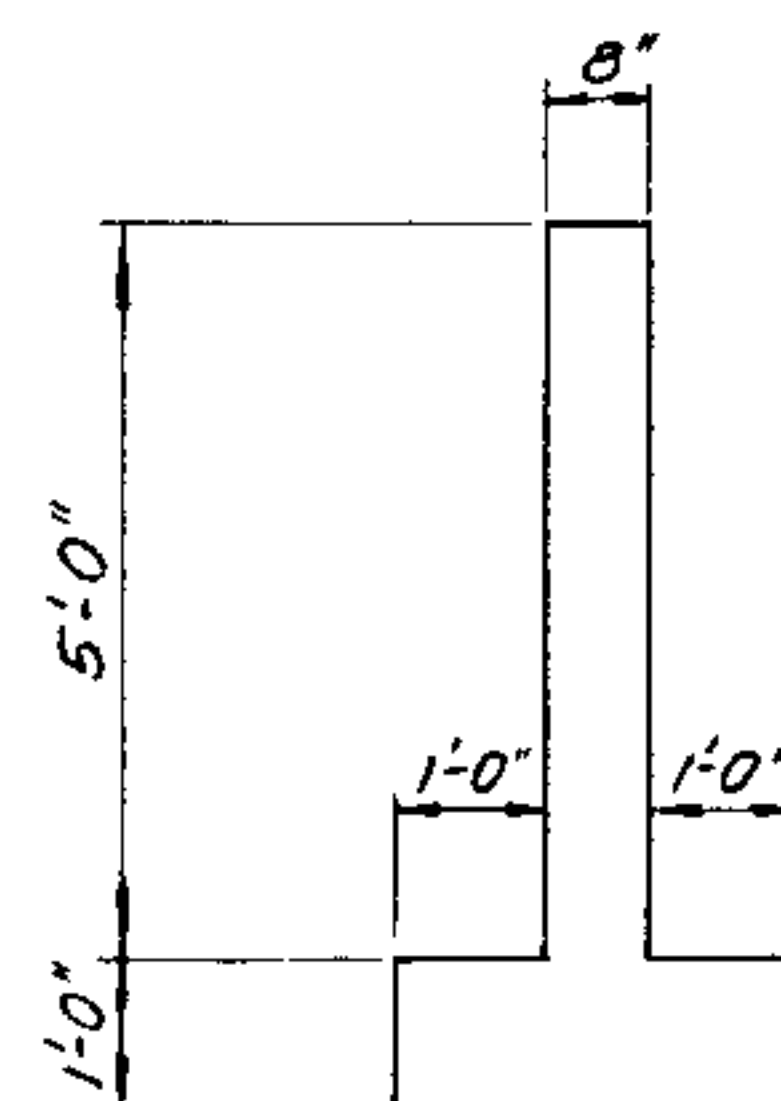
SECTION C-C
Scale: 1/2"=1'



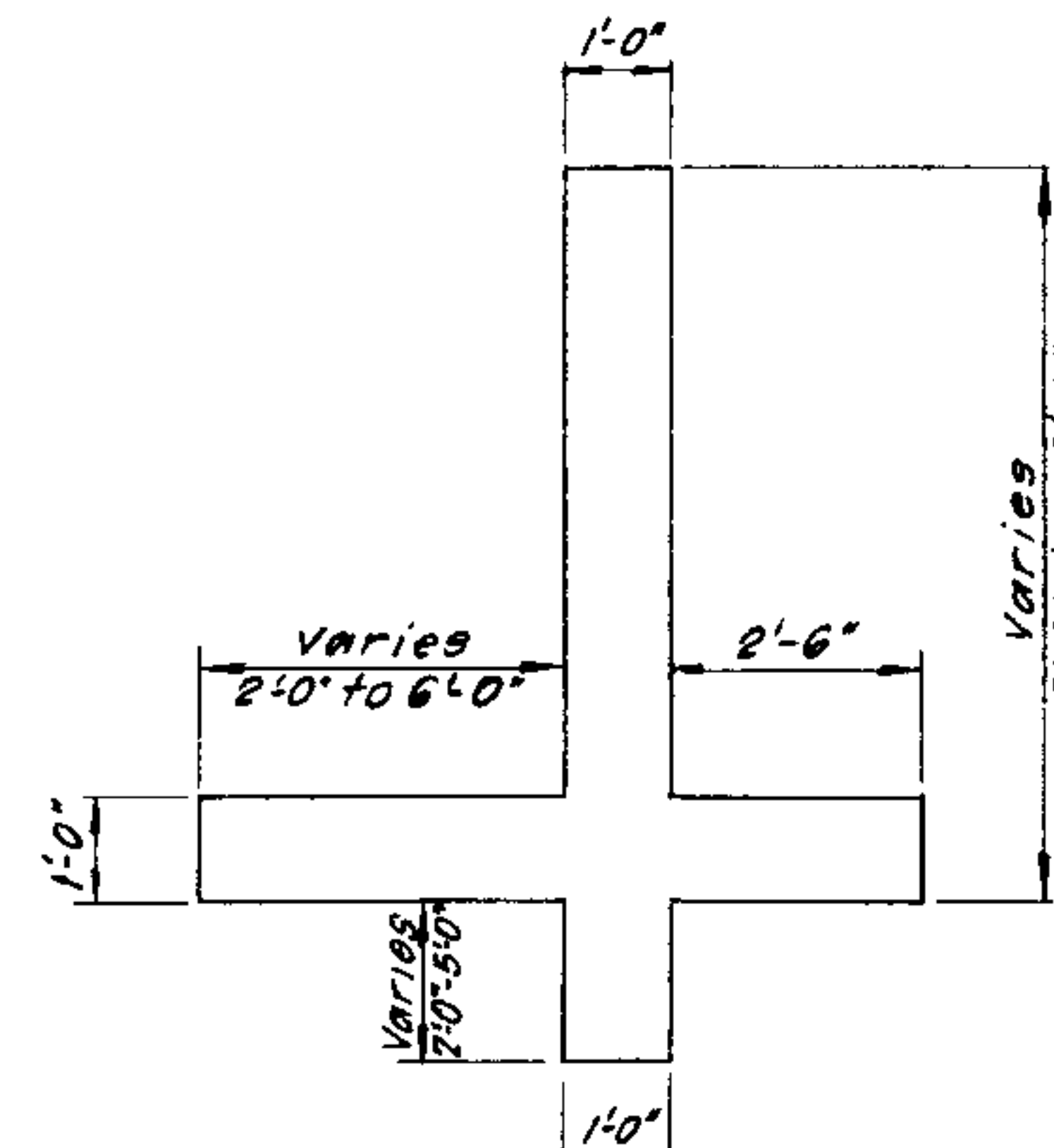
SECTION D-D
Scale: 1/2"=1'



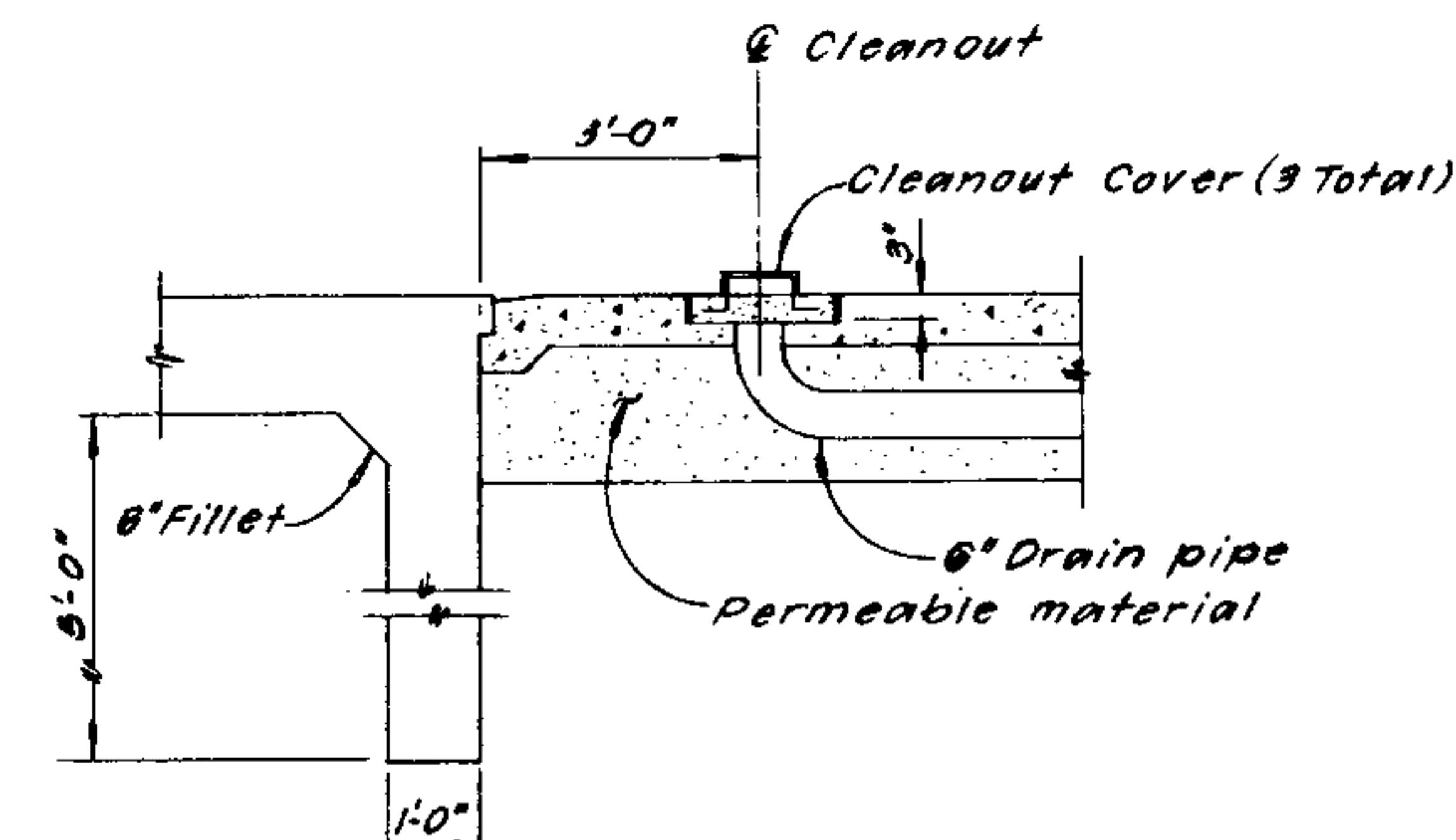
DROP INLET
HALF PLAN
Scale: 3/8"=1'



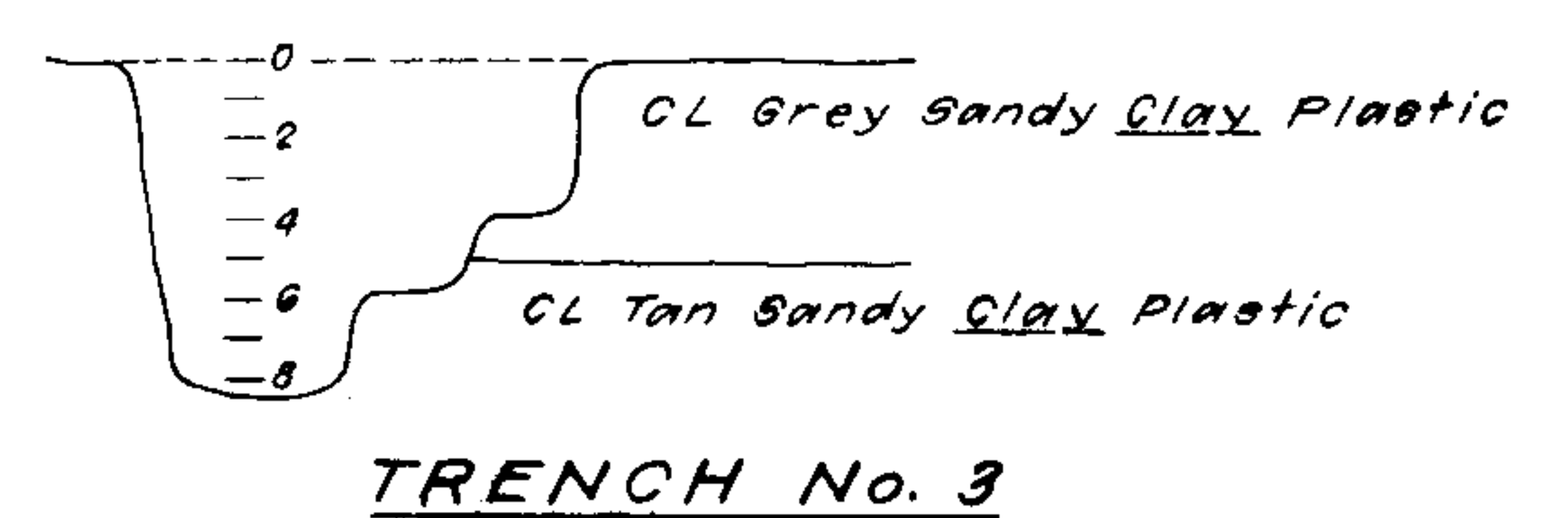
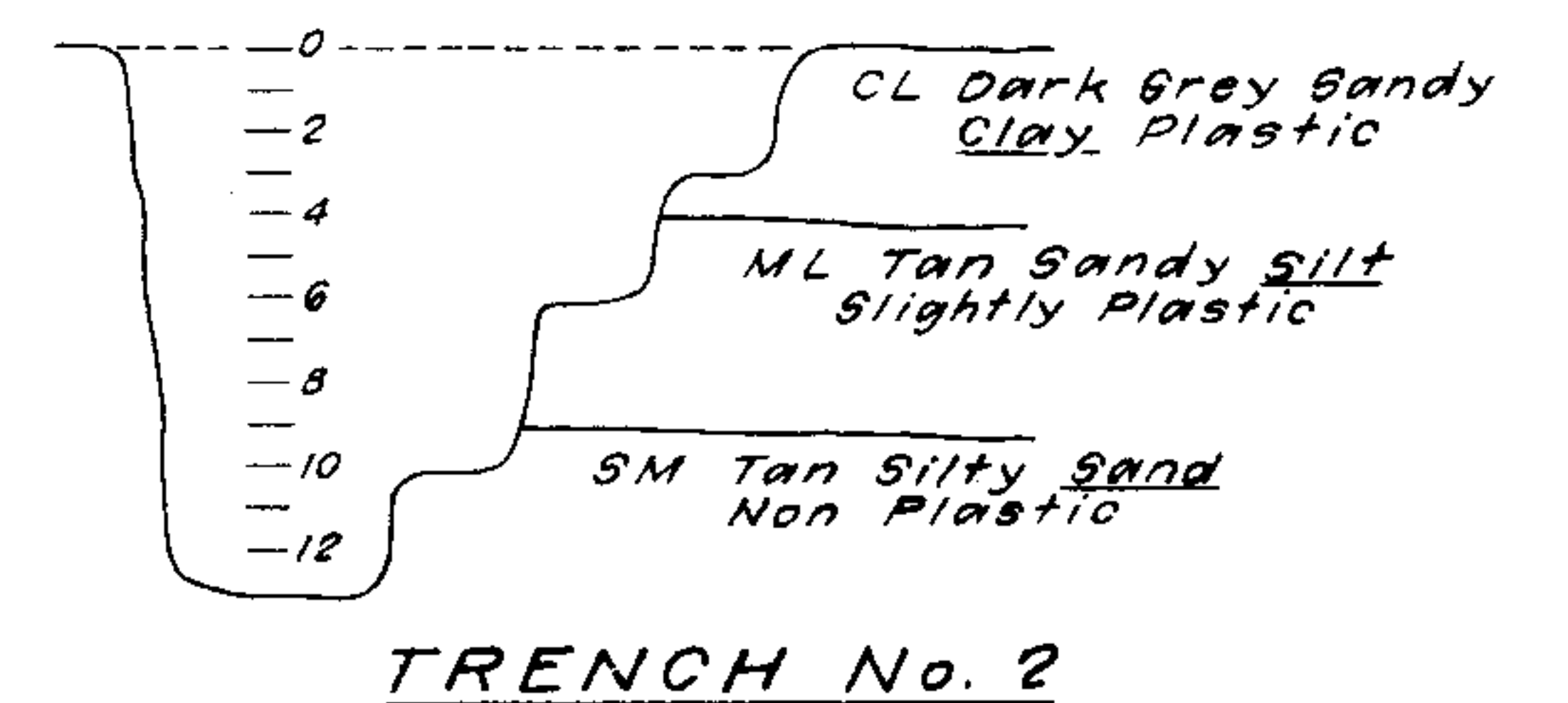
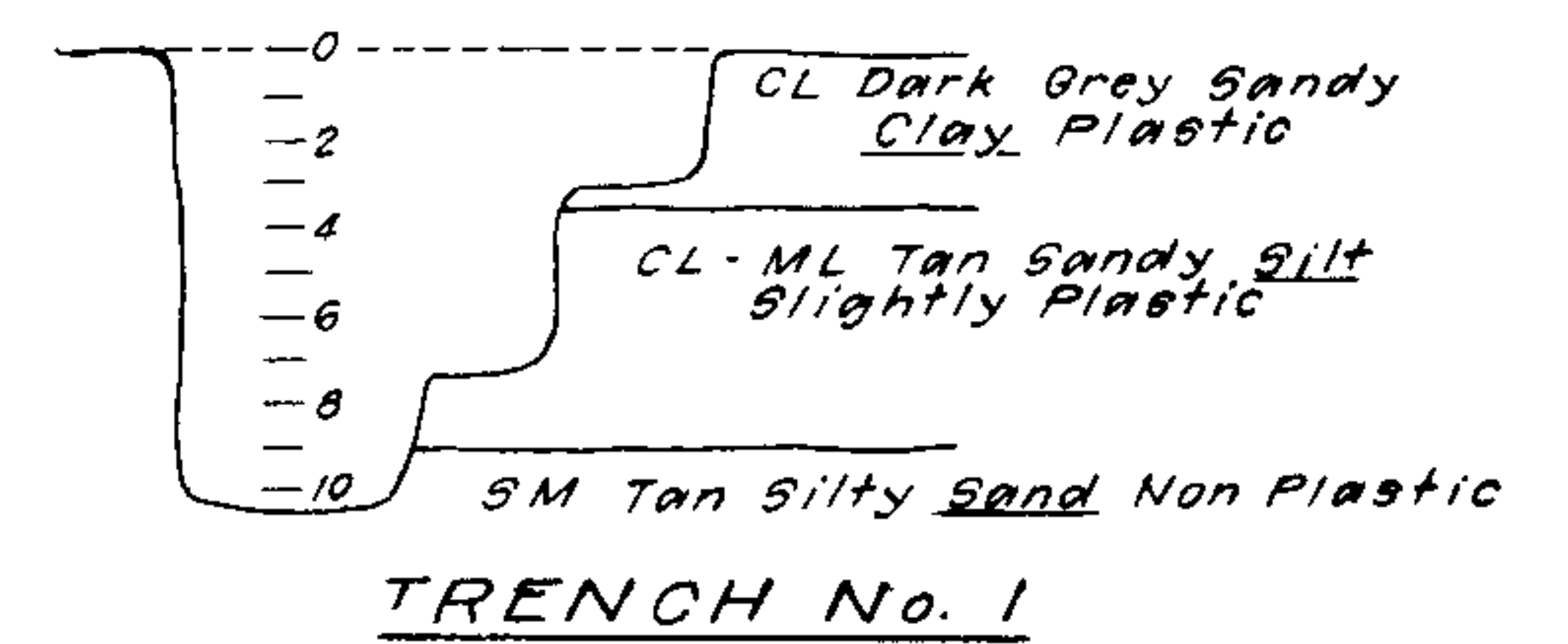
HEADWALL EXTENSION
SECTION E-E
Scale: 1/2"=1'



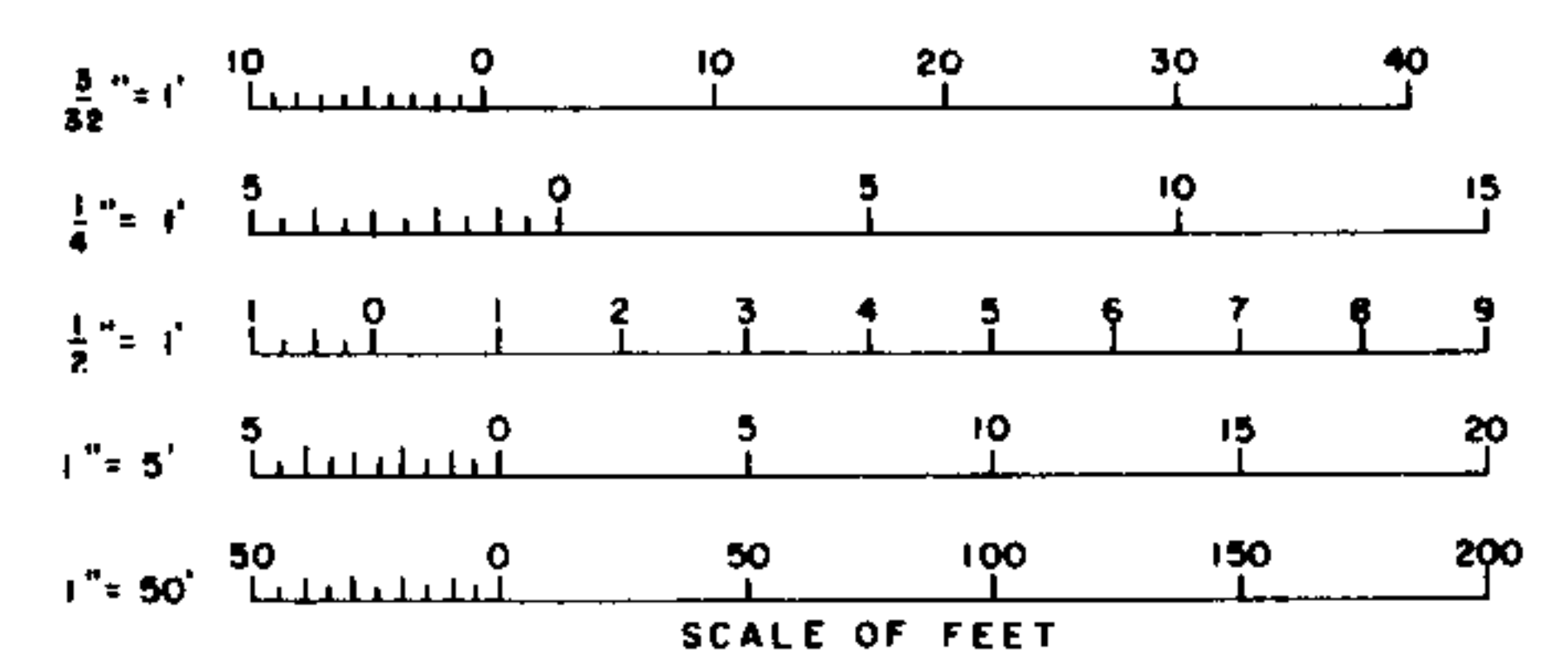
HEADWALL
SECTION F-F
Scale: 1/2"=1'



SECTION G-G
Scale: 1/2"=1'



This spillway design is for an erodible foundation. This drawing along with drawing no. 8 would normally replace drawing no. 3, which is for a non-erodible foundation. This design was selected to illustrate several types of design and construction features.



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THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF SAFETY OF DAMS

SWEETWATER DAM AND RESERVOIR

ALTERNATE SPILLWAY

PLAN, PROFILE AND SECTIONS

SUBMITTED:				APPROVED:				DATE:
APPROVAL RECOMMENDED:				APPROVAL RECOMMENDED:				
REV.	DATE	DESCRIPTION	DESIGNED	DRAWN	CHECKED	REVIEWER	APP'D	
DRAWING NO.				SHEET NO.				5

